CALIFORNIA ENERGY RESOURCES CONSERVATION
AND DEVELOPMENT COMMISSION

STAFF WORKSHOP
FUEL CELLS IN CALIFORNIA
OPPORTUNITIES AND CHALLENGES

CALIFORNIA ENERGY COMMISSION
HEARING ROOM A
1516 NINTH STREET
SACRAMENTO, CALIFORNIA

WEDNESDAY, MAY 31, 2006
9:00 A.M.

Reported by:
Christopher Loverro
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APPEARANCES

COMMISSIONERS PRESENT

None

STAFF PRESENT

Art Soinski, Ph.D., EPAG Team Lead

Martha Krebs, Deputy Director for R & D

Kenneth Koyama
Electricity Generation Research Office

Rob Taylor

ALSO PRESENT

Nancy Garland, Technical Development Manager
DOE

Lutgard DeJongue

Darcy Skaggs, Manager EV Technical Center
Southern California Edison

Marianne Wu, Director of Technologies
MDV

Greg Schrontz, Inside Sales Manager
Jadoo Power Systems

Stephanie Hamilton, Manager
Distributed Energy Resources
SCE

Gopal Shanker, President
Recolte Energy

KR Amarnath, President
KSON International, Inc.

Ben Ovshinsky, West Coast Representative
Energy Conversion Devices, Inc.

APPEARANCES (Continued)

ALSO PRESENT (Continued)

Jack Brouwer, Ph.D.
National Fuel Cell Research Center
University of California

Dan Rastler, Technical Leader
EPRI

Kevin Harris, Sales Manager
Hydrogenics

John Addison, Publisher and President
California Hydrogen Report

Bob Remick
Colorado Fuel Cell Center

Mike Binder
Mike Binder & Associates

Gary Simon, President and CEO
Acumentrics

Mickey Oms

Angela Moore, Sales Manager - Government Accounts
Plugpower

I N D E X

I N D E X (Continued)

P R O C E E D I N G S

9:00 a.m.

DR. SOINSKI: My name is Art Soinski. There's been a change in the person who is responsible for conducting this, Bob Glass, who did a lot of the organization and got the speakers and did some of the logistic work, called in sick yesterday and today. So, at the last minute, I had to come in and pinch hit for him.

I am certainly delighted to see the number of people here. It indicates the level of interest in and the importance of fuel cells in the future of California in both stationary and transportation applications.

We are certainly all aware of the challenges of fuel cells with respect to cost, technical issues, regulations, and other implementation barriers.

The purpose of this workshop in general is to help us gather information on the current technical status and commercialization prospects for fuel cells.

We will hear from a group of experts in both the stationary and transportation fuel cells.

We also want to hear from you, the audience. The information we receive will be of great use to us as we go forward in our analysis of fuel cell technologies and strategize for future PIER investments to accelerate the development of commercialization of fuel cells to the benefit of California ratepayers.

The Energy Commission is not new to fuel cells. The Commission has been funding fuel cell research development and demonstration activities for approximately fifteen years. The first fuel cell project I managed here was actually for a low carbonate fuel cell demonstration at Pacific Gas and Electric San Ramon. This was followed about two years later by the Santa Clara demonstration, which was a two MW project.

We have funded a number of projects since then, but I am not going to go into details on that, just to indicate that we have been looking at fuel cells for quite a number of years.

With respect to the speakers that we have today, it was not easy to decide who to invite. One of our objectives was to get a group of experts that you may not have heard of from before, especially in the forums conducted by the

California Stationary Fuel Cell Collaborative or by the California Fuel Cell Partnership.

Another was to get experts who would engage the audience in dialogues and how to get fuel cells to the point of energy significance in California, which is what we are really after.

The workshop today will start with a Plenary Session with three speakers. You have the agendas, and it will be followed later by sessions on transportation and stationary applications.

At the end of each of the presentations, you will have an opportunity to ask questions and to engage in dialogues with the presenters.

A couple of logistic items. Rob Taylor from SEIC will be assisting in keeping the sessions on schedule without cutting off productive discussions that may be going on.

As you may know, there is a snack bar up on the second floor. Your badge will give you access to the second floor, but not to the rest of the building. There will be lunch on your own. There will be a break approximately at noon. The list of nearby restaurants is on the back of the agenda.

Are there any questions or comments at

this point?

(No response.)

MR. SOINSKI: At this point, it is my pleasure to introduce my boss, Dr. Martha Krebs. Dr. Krebs is Director of the Energy Research and Development Division at the Energy Commission. The Division is responsible for public interest energy research or the PIER Program.

Before coming to the Commission, she was President of Science Strategies and Analysis and Consulting Firm that works with public and private organizations to identify critical issues and opportunities in science and technology.

In 2001, she was the Founding Institute Director of the California Nano Systems Institute at UCLA and UC Santa Barbara. Previously she was a Senior Fellow at the Institute for Defense Analysis where she led studies in R & D Management in Planning and Budgeting.

From 1993 to 2000, Dr. Krebs served as Assistant Secretary and Director of the Office of Science at the Department of Energy responsible for $3.5 billion research program.

From '83 to '93, she served as the Associate Director for Planning and Development at

DOE's Lawrence Berkeley National Laboratory where she was responsible for strategic planning for research and facilities, laboratory technology transfer, and science education and outreach.

From 1977 to 1983, she served on the House Committee on Science, first as a professional staff member and then as Subcommittee Staff Director responsible for authorizing DOE non-nuclear energy technologies and energy science programs.

She received her Bachelor's Degrees and a Ph.D. in Physics from the Catholic University of America. It is a great pleasure for me to introduce Dr. Krebs, who has had a distinguished degree in both California and Washington. I am very glad to have her here as our Program Director.

DR. KREBS: Thank you, Art. Indeed, as you can tell, I have been around a long time, and during that time, I've had a number of opportunities to be engaged by fuel cells, so it is very interesting for me to be here today and to open this up, and I am very interested in what is going to be said today and to learn the current state of affairs in fuel cell technology.

I hope in these opening remarks to stimulate you to think more broadly than just in terms of the technology, or at least to provide us with perspective on more than a fuel cell technology situation.

In addition to welcoming you, I also want to acknowledge the presence here this morning of the Chairman of the California Air Resources Board, Dr. Bob Sawyer, also in my past at both LBA and when I was at DOE.

Let's move on. What I want to talk to you about today, and I don't have a lot of time, is actually a brief discussion of California's energy picture and California energy policy summary.

This is actually the most slides, but I am going to try and get through it fairly quickly, but I do want to give it to you because it is within that context that I would like you to think about what we are talking about today and the kind of feedback that we want with respect to fuel cell technology.

I'll give you a brief sense of where PIER fits into this or how I think PIER fits in and where this workshop fits.

There are copies of my view graphs out front if you don't have them already. The point of this view graph is simply to say that California is a big user of energy. It produces a lot of its own natural gas and petroleum as well as its electricity, but it imports a lot from neighboring states and from other parts of the world.

In terms of natural gas use in the State of California, in addition to the residential, industrial, and commercial markets, electricity generation is a major user of natural gas in the state. We expect that to be the case in the coming years as well.

Looking at it from the electricity side, the use of natural gas is a major resource for electricity production, our resources for electricity at this point in time are fairly diverse, but you can see that we do have a fair amount of coal. Most of that is out of state, and there are expectations for that to change and diminish or at least to become as clean as natural gas.

This is just a picture of how we expect electricity consumption to grow. These charts come from a California Energy Demand Study that was done as input for the Integrated Energy Policy Report that was produced last year. In any scenario unless there are major changes, we expect electricity consumption to be increasing.

Another aspect of the California Energy Electricity Picture is congestion. The 2000/2001 energy crisis occurred in large part because we could not move electricity from north to south, from outside the state to inside the state, and the costs dealing with that congestion and planning for that congestion have increased and are driving a lot of the considerations within the utilities and also the government agencies responsible for dealing with electricity supply.

In terms of transportation, you will see the slide a couple of times. The purpose here is to note that in large measure in California, air emission standards and air emission issues have driven changes in petroleum use and the efficiency of petroleum use over the last twenty to thirty years.

The expectation at this time and we are still expecting California to use a great deal to be continuing to drive. The question is on what kinds of fuels will that transportation picture be fueled.

The other perspective from which to look at energy use in the State of California in increasingly in terms of the governor and the legislature is one of greenhouse gas emissions.

This picture basically or graphic basically shows the sources of greenhouse gas emissions in the State of California. If you within this framework, the emissions from electricity generation are not a huge part significant, but certainly comparable to that from the industrial facilities and small or smaller by comparison to transportation.

This basically puts in perspective the fact that if we are going to deal with greenhouse gas emissions in this state, that it is a larger problem than simply the electricity generation picture. This is the general picture for energy use and production in the State of California.

Now let me change to policy. This view graph is basically a shorthand list of chapter titles in two significant documents, which certainly within the California Energy Commission, articulate what we think of as the energy policy of the State of California and directions in which energy policy and energy activity needs to go.

The first on the left of this slide is the 2005 Integrated Energy Policy Report. The California Energy Commission is responsible for producing this report. It does in conjunction with other energy and resource agencies in the state as well as with the Air Resources Board and the California EPA.

The Energy Action Plan on the right is a document produced by the California PUC in conjunction with other significant energy and environmental agencies in the state.

It is, as you can see, and I am not going to read these to you, but essentially both of them are very comparable and quite comprehensive in terms of covering issues that are important in the California energy picture.

The first of these documents was produced in 2003, the first of the Integrated Energy Policy reports was produced in 2003. There was an update in 2004, so this document represents the third effort by the Energy Commission.

The significant changes, this is my judgement at this point, I wouldn't say this is official, is that in the middle of this document, Electricity Needs Demand Side, Transmission, Renewable Resources, Natural Gas, these were in the heart of the 2003 document and the 2004 update.

What is new particularly in the 2005 document is first a recognition that water and energy in California have a special, and even with respect to other parts of the west, a kind of unique interaction that offer opportunity for both energy and water conservation.

The significant sort of book ending if you will between transportation fuels at the beginning of the document and global climate change close to the end of the document really indicates a focus and a set of expectations certainly within the Commission about the kinds of attention to these energy issues that are expected and certainly within the PIER Program, we have taken them to heart.

I would also say that we are seeing that in the Legislature as well. You might say that the 2005 Integrated Energy Policy Report, both responds and anticipates the direction and needs of California that come to them from both their own assessment of the California energy picture but also what is coming from the Legislature and the Executive Branch.

That is the framework. What I am trying to do with these next few pictures is to tell you sort of historically some of the things that have been part of the energy policy picture in California.

This is one of Commissioner Rosenfeld's favorite view graph which basically shows that the energy policy of California has been to put energy efficiency at a high priority to replace energy supply. Somewhere around 1975, the per capita use of electricity in California went constant in spite of population growth, size of housing, that sort of thing. There is a lot to be said about this, but essentially, this represents a policy decision in California.

Another policy decision that was made in 2002 by law was that by 2010, we would be at 20 percent renewables in our electricity mix. Excuse me, this is where the law says we would be at 20 percent by 2017. The Governor basically made a determination that we would be at 20 percent by 2010 and 33 percent by 2020.

This is a real hard aspirational goal. The ability to do this is also complicated, and the Energy Commission is wrestling with this, but this is one of the policy elements that we are dealing with in California right now.

The reason I am raising this view graph again is that in the framework of greenhouse gas, there are greenhouse gas regulations that have been passed in law led by Assembly Member Pavley that would regulate greenhouse gas emissions in automobiles and trucks and could have a large impact on petroleum use, but they are currently in litigation as you might imagine.

This is the larger policy framework within which both our consideration of electricity and transportation are currently being considered and that certainly within the CEC, we considered that.

That is the most recent activity in the policy arena is the Governor's climate change action plan where more broadly than the transportation sector, he has basically established a goal that by 2010 we will have returned to our 2000 level of greenhouse gas emissions. By 2020, we will have returned to our

1990 greenhouse gas emissions.

That is the energy picture, the policy picture, and where does PIER fit in. We were established in 1997 as part of electricity restructuring. We have $62.5 million from electricity ratepayers. By 2009, we will have $24 million from natural gas ratepayers. We are an applied research program. We have to provide benefits to the ratepayers, and we are expected to leverage public and private investment while advancing science and technology that both enhances California energy situation for Californians as well as providing information to policy makers.

This is not exactly the organizational structure of PIER, but it really reflects if I think about it are some of the important pillars of the energy policy and these three have been long standing from the beginning elements of the PIER Program and reflect essentially what we call the loading order that we will first replace new electricity demand with efficiency with renewables with clean fossil.

Most recently last year, we were authorized by the Legislature to include transportation. Because of what I've said in terms of transportation's role in the energy picture and the greenhouse gas picture, you know, from my perspective qualifies as a pillar. Not the roof, not the foundation, but something that we really have to seriously address.

Where does the fuel cell technology fit in? It is obviously a part of what I think of as clean fossil, whether we are dealing with central station uses, and I would be interested, you know, I think when I first got started in the energy business back in the 1970's, there was a view that fuel cells were central station. I think that over time it moved to thinking of, you know, the first applications might be, at least here, as a distributed resource, and I am interested to know, both from a market and a technological point of view, what do you think. Where are we now?

There is also an opportunity for matching fuel cells, especially with variable or intermittent renewable resources. I won't go into these, but we are very interested in looking at these issues as well. There are policy, things that I haven't mentioned, for example, in the California Solar Initiative, especially what we are thinking about inside the California Energy Commission with its piece of the Solar Initiative, that make us think more broadly than photovoltaics on the roofs of individual homes.

On the transportation side, it is a key concept in the Hydrogen Highway, but it can be more than that because, you know, certainly in the near term, we are still talking about generating hydrogen from natural gas. It has the possibility of reducing greenhouse gasses in combination with renewables or carbon sequestration.

I would like comments on everything. I think that you will probably talk about some of these over the next few hours. One of the major things for PIER is how do we leverage the federal investment both in the electricity and the transportation side.

This is my last slide which is help us identify critical opportunities for future investment in fuel cells. Help us deal with these technology issues, but how do we also from your perspective deal with the continuing issue for PIER, which is ratepayer benefits.

There are also what I think of as critical interdependencies, more so here at the state level than in forming and framing federal research programs. You have to deal with policy issues and the likelihood or the promise of regulatory interventions because that is what happens much more so in the electricity and even in the transportation sector than it does at the federal level.

This is what we are asking you to do today. I am really pleased to be here. I really look forward to what you all have to say, and thank you. I also not only want to thank you for being here, but we've had a lot of assistance from the Fuel Cell Partnership, the Stationary Fuel Cell Collaborative, as well as the Hydrogen Highway Group. So, I want to thank them especially as well.

Thank you.

DR. SOINSKI: Are there any questions? Thank you, Martha, for the perspective on energy policy, which has become extremely important in directing and guiding the PIER Program and also in understanding some of the issues, the significant issues and challenges that California faces from the supply side as we are all aware.

We will now go into the Plenary Session.

We have three speakers. First, we are going to get the US Department of Energy perspective, a very significant program, something that we need to leverage with and something that the PIER Program has worked with for some time.

We are going to get a venture capital investor's perspective on fuel cells, certainly very important in the environment.

Then we are going to get a utility perspective, which are certainly very important players in energy supply on the electricity sector, both a promoter and some would say potentially an obstacle to distributed generation. So, it is very important to understand really where utilities are coming from.

We will begin with Dr. Nancy Garland from the U.S. Department of Energy. She is a Technology Development Manager in the Office of Hydrogen Fuel Cells and Infrastructure Technology, unless it has changed.

DR. GARLAND: That's right.

DR. SOINSKI: It is still there, okay. She manages a project in fuel cell research activities at the National Laboratories and Membrane R & D in industry and at universities.

She is on the Advanced Fuel Cells Executive Committee for the International Energy Agency.

Prior to coming to the DOE, Nancy was a research chemist at the U.S. Naval Research Laboratory where she carried out experimental studies on chemical kinetics and dynamics.

She has been educated at two distinguished institutions of higher learning in California, the Scripps College and the University of California Irvine. She carried out her post-doctoral studies at SRI International in Menlo Park, California, so certainly California.

Dr. Garland, it is my pleasure to welcome you to provide an overview of the U.S. DOE Fuel Cell Program.

DR. GARLAND: Thank you, Art. It is my pleasure to be here. I would like to thank Dr. Bob Glass and the California Energy Commission for inviting me here to talk about the DOE Hydrogen Program's Fuel Cell Program.

This is an overview of the talk. I will start off with the energy challenges that are facing us both in the State of California and nationally and globally. I will discuss some of the efforts that the U.S. Department of Energy is taking to address these energy challenges, both in the near term and in the long term.

I'll then discuss our Fuel Cell Program, mainly focused on fuel cells for transportation and there mainly focused on polymer electrolyte membrane fuel cells. I'll describe our RD & D, the Research Development and Demonstration Plan because this shows you how our program is planning to carry out its RD & D activities for the next ten years. I will mention some of our current and future projects.

Last, I will give you some program contact information or places to go for future information. I've brought along with me, but I won't discuss tax credits that have been provided in the Energy Policy Act, which was passed by Congress last year. I can describe for you if you would like to hear about partnerships that our Program is involved with, including the California Fuel Cell Partnership.

I also have information with me on Well-to-Wheels studies on basically energy use and greenhouse gas emissions for fuel cell vehicles which are fueled by different types of fuels and also competing technology such as diesel hybrid electric vehicles.

First for energy challenges. This plot here shows millions of barrels per day as a function of year. We've got this line here, US Production of Oil. You can see it is decreasing. Then these lines here illustrate the demand for oil for various parts of the transportation sector.

You see the demand for light duty vehicles is relatively constant, but the demand for light trucks, including SUV's and heavy vehicles, is increasing. There is a gap between the amount of oil demanded and the amount of oil which can be produced. This gap is increasing with time, and this is driving why we are here today, at least, in part for transportation.

That is our energy challenge. On this slide, we see some of the approaches that can be taken to tackle this energy challenge. Again, this plot is millions of barrels of oil per day as a function of time. The top line indicates the amount of oil demanded, assuming the status quo. That is if there is no change at all, and it is increasing.

If we introduce energy gains such as

using hybrid electric vehicles and lighter weighting materials in these vehicles, we can reduce the amount of oil demanded, but eventually the amount of cars on the road and the number of miles that are driven by those cars are going to increase. So, we will still see an increase in the amount of oil demanded.

The only way to sort of end our addiction to oil, as the President said, is to find a substitute. The substitution can be effected by using ethanol as a fuel and by using plug-in hybrids, and those are the near term ways to introduce these efficiencies, and in the long term, by using hydrogen fuel cell vehicles. In that way, we can get complete substitution for the oil demanded, particularly in the transportation sector.

The Department of Energy is working on both the near term approaches and also on the long term approaches for obtaining energy and oil savings. In 2003 in the State of the Union Address, the President announced the Hydrogen Fuel Initiative, and this committed $1.7 billion for five fiscal years, $1.2 billion for hydrogen and fuel cell research and development, and then $ .5

billion for hybrid and vehicle technologies R & D, including things like energy storage and the light weighting materials, which will be important to allow hydrogen fuel cell vehicles to come into the marketplace.

This program is an accelerated plan and a parallel track, both the hydrogen infrastructure R & D and the fuel cell vehicle R & D together. This will enable technology readiness milestone by 2015, allowing industry to make a commercialization decision.

This plan will enable fuel cell vehicles to be in the showroom and sufficient hydrogen fueling stations to support those vehicles by 2020.

As I mentioned earlier, Congress passed the Energy Policy Act last year, and that basically codifies the President's Hydrogen Fuel Initiative, in particular Title 8 refers to hydrogen, so that is where we find the bulk of the hydrogen and fuel cell vehicle parts of the EPACT, Energy Policy Act.

With this EPACT, it shows that the Congress and the President are working together. They agree on a particular plan to achieve the hydrogen economy.

This is the timeline that we envision to achieve the hydrogen economy. We've got four phases. We are in the first phase right now with a strong government R & D role, and we are focusing on technology development. In 2015, we would have the technology would be ready such that as I mentioned early, industry could make a commercialization decision.

In Phase 2, we would see initial market penetration. Those are the early market applications of fuel cells such as for stationary or portable power applications, and we envision those beginning in 2010. Those would also enable the manufacturing base, which would benefit the fuel cells for transportation.

In Phase 3, we would see expansion of markets and infrastructure and the introduction of the hydrogen fuel cell vehicles. That is starting basically in 2015 but then carrying out to 2035, and then finally by 2025, we would begin to see the realization of the hydrogen economy and basically begin to see really significant energy oil substitution and benefits in the air quality.

Now I am going to focus on the DOE Fuel

Cells for Transportation Program. This program is focused mostly on polymer electrolyte membrane fuel cells because those fuel cells can be started up quickly, and they operate at low temperature, again, so they don't require a lot of energy for start up or they don't require a lot of time for start up.

The focus of our program is on 80 KW fuel cell systems operating on direct hydrogen. Listed here are three of the important targets. The goals and the objectives of our program for cost, we want to get to $45 per KW by 2010 and then to get to $30 per KW by 2015. That would be cost equivalent to the cost of an internal combustion engine system today.

Going along with that and as Dr. Krebs mentioned, durability is important. The technical target for fuel cells is 5,000 hours of durability operating at 80 degrees, 5,000 hours corresponds to about a driving range of 150,000 miles.

Other key targets in our program are for distributed and auxiliary power units and portable power consumer electronics. For distributed energy, a really important target is electrical efficiency, and I should say are very difficult to achieve targets.

For APU, specific power and power density targets, and then for consumer electronics, energy density. It is very important to squeeze the size of the fuel cell systems for something that you are going to be carrying around.

For these targets, these are for the early market applications, but we don't anticipate the oil savings from these applications that we would expect to see for transportation applications.

I mentioned that we have Research Development and Demonstration Plan for our program. This table comes from our RD & D Plan, and it lists our technical targets for an 80 KW Fuel Cell System, operating on direct hydrogen. These are various characteristics or properties in the fuel cell system. We've got the status for 2003, 2005, and our target for 2015.

On the top, this is the status for cost, it is for cost estimated at high volume production, that is 500,000 units per year, that is sort of like a nitch market production rate.

We are currently at $110 per KW, which

is a little more, well between three and four times our 2015 target of $30 per KW. Cost and durability are the two most important targets and challenging targets. Also important, precious metal loading, power density so that the fuel cell system doesn't interfere with passenger space or cargo space.

Also extremely important is start up and shut down energy. How much energy does it take to start up the fuel cell and can it start up below freezing temperatures? This is also a subject of recent interest.

We've got technical target tables, not only for fuel cell systems, but for stacks and for components such as membranes, catalysts, membrane electrode assemblies, bipolar plates and so on.

Then you might ask what is preventing us from achieving these technical targets, these barriers. I already mentioned cost and durability, but there are other barriers to achieving our targets including electrode performance. The electrodes got the catalyst diometer and so on.

Water management is critical, and we mentioned before start up time and transportation operation.

To overcome these barriers, we have recently updated our technical tasks. This table here shows our updated list, and, again, we always are looking for feedback too. If you have comments or suggestions on any parts of our RD & D Plan, we are always happy to hear these suggestions.

We have technical tasks in the first column, and in the second column, basically describes how we plan to carry out these tasks. We've got tasks for components such as membrane electrodes, MEA's and so on.

We've got some new tasks. We are planning to do work on gas fusion layers and seals. That is new. We are carrying out R & D on balance of plants. A component such as sensors and so on, and to evaluate performance and determine -- to benchmark status of the technology, we carry out various analysis projects and characterization such as cost and trade off analyses and we benchmark technology constantly to measure the progress in our program. Lastly, we are always looking for innovative concepts, new ideas.

This is an example of a milestone chart

we've got for various different tasks as a function of a year. We've got various different milestones and go/no go decisions. This is just an example, a snapshot out of our R & D Plan for transportation systems, a tasks for sensors for example, and this milestone is to complete development and test low cost sensors.

Here in 2006, we also have a go/no go decision where we evaluation the status of technology and decide whether we are going to continue on the path that we are on or if we are going to change the path and go in a new different direction.

This is the type of milestone chart. We have milestone charts for all of our different tasks, so we track the progress of our program.

Our program is focused on a number of different topics, including membranes, MEA's, catalysts, and bipolar plates. Listed here are the principle investigators that we have right now working on projects for these topics.

These are the stat components, that is the core of our program. We also have work on balance of plant components such as air and thermal water management and stationary and other early market fuel cells.

Work on the balance and plant and the early market fuel cells is delayed this fiscal year due to budgetary constraints. Work I mentioned on characterization and analysis, NIST has a neutron imaging facility which is proving very valuable to look at water management, how to water transports through a fuel cell.

We also have congretionally directed projects work on catalysts, on start up at cold temperatures, and demonstration projects. So, those are the projects that we are carrying out now.

Here are some of the recent accomplishments from our program for cost and durability. For cost in 2002, we were at $275 per KW, now three years later we are down to $110 per KW towards our 2015 goal of $30 per KW, so making progress in that front.

For stack durability, the goal was 5,000 hours of durability, and we've doubled the durability over the last couple of years there.

In this corner, this pie chart shows the break down of the cost of the fuel cell system, 80 KW operating on direct hydrogen projected at a high volume production. You see that the bulk of the cost of the fuel cell system is taken up by the fuel cell stack, and this pie chart represents the stack. The bulk of the cost of the stack, it comes from the electrode and basically it is from the platinum catalyst because the platinum is very expensive.

This chart here shows the average cell voltage as a function of time for a fuel cell stack. In this particular case, your technologies, and it shows that the degradation and the performance over 4,000 hours, and the performance is degraded about ten percent. So, this is showing just an example of how we are able to increase the durability of our fuel cell systems.

I'll mention a couple of other developments. Work at Dupont and UTC on membrane electrode assemblies, this shows the performance degradation rate as a function of membrane swelling. As the membrane swells, the decay rate increases, so that Dupont UTC, they are working on decreasing the amount of swelling in their membrane, and that decreases the degradation rate.

Work at Brookhaven National Laboratory

is working on this catalyst project. They are working on basically having a noble and metal core and platinum shell around the N & M core to increase the amount of platinum that is available in the fuel cell.

They have been able to show with their new catalysts four times the mass activity of pure platinum alone. This is some very promising research carried out of Brookhaven.

This shows are fuel cell budget over the last several years. The bars on the left hand side are the President's request and the bar on the right are what was available from Congress. You can see that the request has been relatively steady. The smaller bar, the yellow bar, is probably the most important. That is the request is for stack components.

The request, as I said, has been relatively steady. Budget has been around $50 to $60 million per year.

We have recently our office held a solicitation and a lab call for future projects. This lab call and solicitation closed last month. Proposals are undergoing review right now. The size of the solicitation was 100 million, and that is just for the DOE Federal share for projects that would cover two to four years.

The primary years, as I mentioned before, is on fuel cells for transportation because that is where the oil savings are. Industry can manage the development of fuel cell systems, complete systems, that is more their specialty, so that the Federal R & D is focused more on developing components and materials.

These are the topics of the solicitation: membranes, catalysts, water transport, cell hardware, the effects of impurities. Again, we are always interested in innovative concepts.

One of the topics also was for a stationary demonstration. This was kind of unique. It was in combination with solicitation carried out by the European Commission, and so this was a joint U.S./European stationary demonstration project.

I do want to mention that the Office of Basic Energy Sciences within the Department of Energy, does have an open solicitation. This is for basic research for the Hydrogen Fuel Initiative, catalysts, membranes, and other important topics. The deadline for preapplications for this solicitation is July 6. That is more than a month away, and further information about this solicitation can be found on this website.

Our program has a technology validation effort I just want to briefly mention. This is a learning demonstration project in which four teams are composed of energy provider and a automaker and fuel cell manufacturer. Each one of these teams is validating a technology and basically what that is doing is telling our program what the status is of complete systems.

The purpose of this program is to evaluate technology under real world conditions. I mean the rest of our fuel cell program and hydrogen program, experiments are carried on and components in a laboratory under very controlled conditions. This technology validation effort is to evaluate the technology under real world conditions.

It is not a commercialization demonstration, but it is basically to tell us what the technology status is, and we have just started receiving data from this program, such as the fuel economy, fuel cell vehicles which is slightly lower than would be hoped for. So, there are challenges, but this is telling us where the challenges are, and it tells us where we should focus our research efforts.

Listed here are the technology validation teams. For further information, this website here, www.hydrogen.energy.gov, you can find a wealth of information on our program, on hydrogen, on fuel cells. This document right here is our annual progress report. In that, you find technical summaries of each one of the projects in our program, and this is updated annually.

Our projects are reviewed independently every year, and we use the input from the reviewing process to make our funding decisions. This document here is a summary of our review process for last year. Two weeks ago we had a review in Arlington, Virginia, and the results of that review will be coming out probably in September.

Sometimes Congress will request reports from us, and this is an example of a report to Congress on solar and wind technology, where the technology is, and where we can go forward with the technology.

This is an example of our web page. We are starting as the technology advances, we are looking towards manufacturing efforts, how will we be able to scale up the technology. So, we held a workshop last year on manufacturing R & D for the hydrogen economy.

This road map here reflects the results of the workshop and the plans for the future for our manufacturing activities.

Last, each of the offices within our Hydrogen Program has RD & D plans. I mentioned the one from our office, and here is a RD & D plan from the Fossil Energy Office.

With that, I will close.

DR. SOINSKI: Are there any questions?

UNIDENTIFIED SPEAKER: Did you mention anything about hydrogen storage (inaudible)? Is that part of your --

DR. GARLAND: Yes, it is, that is part of our program. That is probably the most critical technology in our program is hydrogen storage. That is a very difficult problem to solve. Right now it is about $30 million per year. They are pursuing chemical hydrides, metal hydrides, carbon based hydrogen storage, and advanced technologies. Not really storing of gas based hydrogen, that is really an advanced technology, so we are not focusing our R & D dollars there.

UNIDENTIFIED SPEAKER: I wonder if you could elaborate a little bit on these go/no go decisions that are embedded in this first phase. What is the nature of them and what would be the consequences?

DR. GARLAND: I can give you an easy answer. Our program for a number of years was carrying out research and development on an on-board fuel processing in which fuel, say for example gasoline, was carried in the vehicle in an on-board reformer would convert the gasoline to reformat which could be used in a fuel cell on board a vehicle.

It looked like that the research was not developing at such a rate that this technology would be able to meet the near term targets that it was supposed to achieve, and so the office had an independent panel evaluate the status of technology, including the ability to start up and to meet the start up energy requirements. It was taking half an hour for these fuel processors to warm up. All that energy was not moving the vehicle.

Two years ago the panel recommended that the office discontinue R & D on an on-board fuel processing. So, the decision was, yes, we are going to stop the on-board fuel processing R & D, and so those projects were stopped.

MR. DEJONGUE: (Inaudible.)

DR. GARLAND: Yes. In fact, I believe this year there is a go/no go decision on storage by carbon fibers or nano tubes or so on. Further information can be found on our web page in the RD & D Plan, but, yes, this year there is a go/no go decision in hydrogen storage on carbon.

MR. SKAGGS: Hi, I am Darcy Skaggs from Southern California Edison. I see in your Chart 17 the requested funding stay stable, but the available funds decreasing this year. Any forecasts for next year?

DR. GARLAND: We have no idea. We changed appropriation committees this fiscal year, and so Congressionally directed projects took up some of the funds, and we have no idea.

DR. SOINSKI: Anything else?

(No response.)

DR. SOINSKI: Thank you. I think there are three very important points that Nancy made. One is the whole uncertainty at the federal level as to funding, which certainly impacts PIER investments.

Second is the number of partners that were shown, research partners, which are greater than fifty or sixty in number, certainly a far larger number than a program like the PIER Program could ever hope to really participate in.

The third point was the last slide which showed a road map. One of the things that PIER Program is doing is preparing road maps, both at strategic level and at the individual program level. One of the purposes of this workshop is for us to get input into our road map, not only for fuel cells, but for other distributed generation technologies. We certainly appreciate comments on those both here and via e-mail. My e-mail address is on the bottom of the agenda.

Our next speaker is from the investment community. Dr. Marianne Wu is the Director of Technology for MDV where she focuses on energy and materials investments.

Prior to joining MDV, she was Vice President of Marketing at ONI Systems, where she was responsible for project strategy and market development. Earlier in her career, Marianne was a consultant at McKenzie and Company where she advised major technology clients on strategic and operational issues.

She has conducted state of the art research on optical devices at Stanford University. She started her career as a design engineer at Nortel Network where she developed high speed networking technologies.

Marianne earned her Bachelor's Degree in Applied Science at the University of British Columbia and her Master's and Doctoral Degrees at the School of Engineering at Stanford University.

I first heard Dr. Wu several weeks ago at a nano technology forum sponsored at the University of California Berkeley, and I was so impressed by her perspectives and insights, I decided that she was somebody that I think all of you would very much enjoy hearing.

The title of her talk is "Building Fuel Cell Companies, Challenges and Opportunities". Dr. Wu.

DR. WU: Thank you, Art, and thank you to Bob for inviting me, and the California Energy Commission for inviting me as well.

I am going to talk from a slightly different perspective than our speakers this morning. As Art said, I represent the investment community, and our interests are a little bit aligned a little bit different in the perspective.

I am going to start by giving a quick overview of MDV so you can get some sense of the lens from which I am discussing this perspective. I am going to talk a little bit about what is happening venture largely where there is an increasing focus and shift on what we call "clean tech" and I will talk a little bit about fuel cells and how we see those markets and what the opportunities and challenges are there.

MDV, we are founded in 1983. We are over twenty some years old. The key points on this page is that we have an early stage focus. That means we get involved very early. We are bringing technologies typically -- thirty to forty percent of our companies are coming straight out of the lab and getting on from there into technologies that gets to market.

The logos at the right hand side of the page perhaps better represent than the next page that we invest in a broad view of industry. There are some very focused energy or clean tech investment funds. We are not one of those. We are a mainstream funds. We invest in energy and materials, internet services, life sciences, semi-conductors, and software systems.

When we are looking at investments, we are looking across the lens of this broad spectrum, and we are looking for the best opportunity across all of these investment areas.

I will highlight three investments for the audience today. The top three over here Nano Solar and Energy Innovations are PV companies and Jadoo Power Systems is a fuel cell company, and these are the three investments that we have announced in this energy and materials sector.

What do we look for if we are looking across? I would consider this to be pretty general across the venture community. This happens to be MDV's version of this statement, but I think this is pretty general.

What we look for is breakthrough engineering and science going after huge new markets. I think there is very little question that energy is a huge market. You can't talk about anything in the energy sector without talking about billions of dollars.

The opportunity for disruptive technology to displace incumbents with a significant value of proposition. So, I am going to come back to this throughout the back half of the talk in terms of significant value proposition.

A lot of venture investment, and certainly start up formation, is about having a value proposition which is for the most part primarily economic when you are trying to get people to shift behavior. There has to be some economic component to that value proposition.

Successful channel for start ups. You know we have talked certainly about utility scale investment. That is a very difficult channel for start ups, and there are pieces of the energy sector that are perhaps not so well suited to venture, diversified customer and high margin business.

The last thing I will put is that we are looking for market solutions and not technology platforms. I did say thirty to forty percent of our companies come out of a lab. Often people think they have great technology platforms, but they are not sure what they are for, and so companies need to be formed around market problems and market solutions.

Shifting over to energy, I think this is relatively obvious, but I will cut the context for why I think there has been a lot of focus now on energy in the venture community.

One, certainly there is a demographic trend today where we are multiplying. The world's population is just increasing, and as a people consume a certain amount, I think the per capita consumption is increasing as well as the world's population. So, we have a big force there.

Economic. We are bringing a whole new set of populations on board in terms of economic development. So, when we look at the emerging economies, Brazil, Russia, India, China, there is a huge set, a huge population who is now coming on stream to consume more resources.

Finally certainly there is environmental trends that we are trying to operate now within the resources, so there is much more focus now on how do we have a sustainable footprint.

Those things put together say that there is a fundamental shift in the demand curve for materials and energies, so we have a lot more demand and supply is relatively constrained or dwindling depending on your perspective. There are supply constraints and there are strained resources.

The last point relates to the fact that we consume more just because (indiscernible) that we have more things, whether they be electronic or technical gadgets that we are consuming more power all the time.

Those were the macro trends that I think have shed a lot of light on the energy problem as a promising investment area. The other reason that I think it has become very interesting is that there it is very fruitful from a technology development perspective that you can have disruptive innovation that comes into this marketplace.

One is certainly nano technology and the ability to structure materials at the molecular level and give you more capabilities now in terms of energy, whether it be catalysts or fuels or PV.

Tying on to that, materials design is becoming much more sophisticated. We've seen I think a much bigger focus on interdisciplinary efforts, so you have chemistry, biology process technologies coming together, and those are particularly fruitful if you look at areas like energy which are multi-disciplinary problems.

Manufacturing technologies are improving, and then IT technologies have become very advanced now in networking, communications, in computing. A lot of those technologies have become cheap enough that they can be more deployed globally and you can think about things like sensor networks and demand management as an off shoot of advances in the communications and computing infrastructure.

I had said that the interest in energy is growing. This is just a quick snap shot from the clean tech venture network, and you see in yellow the number of deals on an annual basis and in blue the number invested. This is just for North America, so this is for Canada and the U.S.

Over the six year period from 1999 to 2005, we had $8 billion of venture money invested in this sector, and I'll come back in a moment to what's counted inside of clean tech.

This is the way clean tech likes to classify it, but I kept it in here because I thought it was interesting. If you look at '99 to '01, there is $3 billion invested in 360 deals. You see the growth here of '02 to '05, 618 deals and $5 billion dollars invested.

This is considered in Clean Tech Venture Network, and there is sort of a tracking firm that keeps track of investments. They are calling this the learning and diversification phase. I think that is true. I think that people are moving, and certainly more firms have entered into the energy investment area.

As a main stream firm, MDV has been investing in energy and materials for four years, that is a long time for the main stream firms to be in this sector. We have seen in the last two years many different firms moving into this sector, and I think there is interest across the broader spectrum of investment opportunities.

If we look at the segments that got counted in this Clean Tech, and the terminology, it is a little bit messy, but they have 40 percent being invested in energy. I would probably argue that probably a good deal of this 15 percent is materials and nano technology was really energy investment as well. The classifications can be a little bit fuzzy.

You can certainly see that somewhere around at least $4 billion in North America was invested by the venture community into energy technologies. Of that, generally about 50 to 60 percent of it tends to be focused on supplies, so energy generation as opposed to infrastructure or efficiency.

This is just a historical snap shot. I don't mean for you to take anything from this but what's happening in the venture community.

If we shift over and talk about fuel cells, fuel cells can certainly be broadly deployed across a number of markets. When we talk about energy footprint, we tend to think about transportation and electricity generation at least distributed scale or perhaps a central station scale.

When we look at fuel cells, we are looking at them across a broader spectrum of application, so there is certainly stationary distributed generation where we are displacing power from the grid, and this is relatively large scale power transportation where we are competing against internal combustion engine at still lower scales, but still pretty large power output.

Transportation for the auxiliary power unit and then portable at the low end, where we are not portable in micro, which are just different in terms of their power consumption.

These ones don't tend to be very energy footprints intensive, you know, we are not going to have a lot of displacement of oil. We are not going to have a lot of displacement of emissions. In some ways, these are perhaps easier segments for start up companies. Certainly my comments are all around start up companies to get started.

I should say the venture community is typically looking for a return on their investment in a five to seven year horizon. So, that very much impacts the kinds of things that we can be investing in. So, if we are looking at the Hydrogen Highway and fuel cell vehicles to becoming in around 2020, that is really not an appropriate investment horizon for venture firms to be involved. So, although venture is very excited about energy and clean tech, we have to be very focused around the opportunities that we can pursue.

This is certainly an incomplete set of companies that are in the fuel cell space, but if I just map power from small 10 Watts and look at three primary categories of applications, I have many on the previous page, but if we just break it down into portable, stationary, and transportation, then you will see that portable is primarily for electronics. There is a number of certainly large companies pursuing this area, but there is also a number of venture back start ups who are going after in this category, I call them the "micro power", so targeting cell phones, for example.

Jadoo Power Systems I mentioned was one of our investments. They are slightly higher, they are looking at more industrial portable application. If I look now at stationary number of companies, some of whom will be speaking later this afternoon, I believe there is less investment, venture investment in this category, although there is certainly some. I think there are some representatives of ION America here today, and there is probably a few other companies funded here.

If we get into transportation, lots of big players involved, but certainly less venture backed companies.

There is going to be a lot more detail than there has been this morning about this state of fuel cell technology. I will just say it is still very early days. So, if we think about the way we look at technology in a very simple way as performance, cost, and durability, performance fuel cells certainly are efficient, they are modular, and they provide high quality power. These are obviously very positive attributes. Cost because it is still so young, cost tends to be very high, and we have heard this morning that this is just a problem plaguing fuel cell commercialization and durability, again, it is early days, so we just don't necessarily have the track record yet for some main stream applications.

I would argue that one of the primary problems today is cost. So, if the issue is cost, then we should focus on high value energy, so we should focus on a cost umbrella that is very high so that we have more room to play with.

Not all watts are equal. I said at the beginning, there has to be a fundamental value proposition, so we should think about the relative value of different kinds of energy, and then target on relatively high values of energy so we can displace.

These numbers are only roughly correct, so don't -- they are just meant to be indicative, so wholesale power is cheap. Grid wholesale power is cheap. At the retail, you know, you paid for transmission, there is certainly a higher point, and then peak is much higher.

For example, we've seen an explosion in solar power, partly it is certainly because of rebate programs and the incentives that have been made. Partly it is because this number is probably low in California for some of the commercial enterprises, so this is a big problem, and so you have a big price umbrella that you can come in under.

Let's focus on things that give us that pricing umbrella. Portable power, if you look at batteries and non-rechargeable batteries, and depending on what battery you are using, the prices are all over the place, but portable power is a tremendously valuable. So, power that I have in my pocket, I pay a very high price point for that equivalent watt hour.

In transportation, transportation is expensive and certainly has a huge energy footprint, but it doesn't give me the same kind of pricing umbrella as some of the other pieces.

If I now walk through sort of portable, and I am just going to touch briefly on portable stationary and transportation markets and talk a little bit about what we are seeing. This is the typical sort of market opportunity chart that you will see a lot of micro-power fuel cells companies coming in with.

The fundamental problem that they are trying to solve is your battery problem, so consumers are notoriously unhappy with the battery lifetime of their cell phones and their laptops and all of their various gadgets. This problem is only forecasted to become worse because more and more features are going into your phones and your laptops. So, the power of demand budget is going up.

At the same time, battery technology is moving along at a relatively incremental curve, and so Nancy talked about getting watt hour per liter metrics, that volumetric energy density up for fuel cells. This is very much the value proposition that they come in with. There is this huge run time gap in terms of portable devices today. Fuel cells provide very high energy density in a small volume, and they become part of the solution to this. Some variance of this slide is what most portable companies will come in with.

It is certainly true in the micro segment, the cell phones, PDAs and laptops, there is a power crunch, particularly I think in Asia markets, they have seen a lot of innovation in terms of chargers that can be available for train rides, extended commute times.

Slightly higher in the portable segment, power tools, broadcast cameras, military first responders, these are still portable applications, but more industrial in nature.

If I look at the challenges which was part of my charter, the challenges in the micro segment is that the incumbent technologies are batteries and power cords to recharge. So, battery cords in North America -- if you rule out they are still pretty ubiquitous, and then if you count in your car chargers and your difference ports, there is a lot of different -- although people complain about battery lifetime, there is not yet the great willingness to pay for this lifetime, so this becomes a little bit challenging.

From a market landscape perspective, consumer electronics is vertically integrated. A lot of the Japanese and Asian manufacturers have battery companies and fuel cell development that they are pursuing themselves, which makes it more challenging for a start up to enter.

Then fuel infrastructure, to the extent that it is hydrogen becomes -- or even methanol can become problematic with respect to having fuel or transportation. So, if you want to go on planes or distribute and shift cargo, infrastructure can be challenging.

What we've seen and what we believe is a great early entry point into the portable market is applications where customers are dealing with emission critical applications, and so they have a much higher willingness to pay.

Jadoo Power Systems, our portfolio company, has had a lot of success with first responders military and broadcast camera operators because these are people who fundamentally care about the quality of their power and the availability of their power, so they have a higher willingness to pay. You will see this a lot with early companies, that you need to find a market segment that is willing to pay, that is willing to work through some of the start up issues because they really value the attributes that you are bringing.

I have had my five minute warning, so I am going to go through these very quickly. Stationary applications, the opportunity here is of course that fuel cells are ideal distributed generators. They enable power to be sited at the point of use. The technology is very promising, and I think you guys all know this, so I will keep moving.

From a venture perspective, distributed generation is not a market that exists today, so you would have to create the market. In part, you can do that if you have technologies that are very disruptive and they change, again, I think the economics of the situation. There are certainly utility questions on distributed generation as well.

Some numbers I believe they are from EPRI, there are 234 GWs of DG installed in the U.S. and 81 percent of that is stand by and back up power, and 86 percent of those gen sets are internal combustion engines. So, diesel gen sets are just very cheap. It is a tough point to come in if you are competing as a back up power solution.

The economics here are critical. We need to get to around 10 cents a KWh or under 10 cents a KWh, and I think Nancy, you had had $750 per KW installed, I said less than $1,000, but roughly the same range. We really just need to get the cost down for stationary to come in.

I know there is a bunch of work being done in this sector, and I am sure many companies who will be speaking later today will be talking about their efforts here.

Transportation, I think this is obvious. There is environmental pressure to reduce emissions, and certainly we need to reduce our dependence on -- there is a homeland security effort as well to reduce our dependence on foreign oil. So, if we increase the conversion efficiency and reduce the emissions if we switched hydrogen based fuel cells.

The challenges here I think from a venture investment opportunity are pretty obvious. You have a very conservative industry dominated by large players who are slow to adopt and who may have quite different interests, very entrenched incumbent technology, fuel infrastructure that you need to now set up a fueling infrastructure to support this economy.

Recently, a lot of growth and other contenders that also address the environmental issues, so certainly the success of the hybrids has become somewhat of a surprise in the auto industry, and everybody is running to hybrid, and now plug-in hybrid, a lot of interest in bio-fuels, whether it be ethanol with E-85 or bio-diesel. These fit a little bit more cleanly into existing infrastructure.

So, my comments are here are to focus on early adopters, busses, fleets, and forklifts as some of the candidates, and then have patience because this is clearly going to be a long term proposition.

My summary chart I am sure will make you happy. I think fuel cell technologies are promising across a number of markets. The technology is extensive and not generally proven. So, as a result of that, I think the key is to focus on -- the thinking in a lot of companies is to focus on large huge markets, killer ops whether they be transportation, whether they be cell phones, but the value part may not be compelling in those markets. So, I think companies should focus on a narrower focus with a strong financial value proposition and find those industrial users, those emission critical users with the high willingness to pay.

Thank you.

DR. SOINSKI: Thank you. Do we have questions for Dr. Wu? Come up to the microphone please.

MR. SKAGGS: Good morning, Darcy Skaggs with Southern California Edison again. The diesel gen set for back up power as a venture investor, do you consider regulation oversight, air quality restrictions, operating hours limitation --

DR. WU: That's a very good point, and so certainly there are issues with gen sets, and they are becoming much more restricted.

Regulatory pieces are important as long as the regulatory pieces are stable, and so this is much more a comment on tax incentives.

The tax incentives can become unstable, and then they are hard to factor in from an investment perspective. To the extent that you have much more regulatory oversight that is starting to control emissions, then it becomes a great investment umbrella to be looking for new opportunities to start, and we've certainly seen that emissions control, clean diesel, and various pieces there.

MR. SCHRONTZ: I am with Jadoo, and I just started there two weeks ago, but I just a touch and feel because when people say fuel cells and how they work, a lot of times they don't understand that, so, I have it here if people want to touch it and feel it, so, thank you.

DR. WU: I should say on Jadoo, a lot of times people think of fuel cells as very futuristic technology. Jadoo is selling products today. I think you see he brought up broadcast camera, and there is broadcast camera operators out there who are using those every day in the field. So, fuel cells is not futuristic as long as you can find the right applications to get started in.

Great, thank you.

DR. SOINSKI: Thank you very much.

One of the interesting points I thought was the five to seven year expectation on return on investment, and we sort of have the same type of issue except we are trying to provide public benefits. That is one thing that I don't really have a handle on, perhaps Dr. Krebs does, is should we be looking at the short term or should we be looking at the long term, or do we try to do all portions of the spectrum, and that makes it really very difficult for us in deciding let's say within fuel cells where we put our focus.

Then also because the fact that diesel engines reciprocating engines are so inexpensive, do we perhaps focus our investments there because there is where we can potential get energy significance. So, those are some of the issues that we really deal with in trying to prepare a road map, and we will certainly appreciate any perspectives that you can have because we do have limitations as to the amount of money we have.

Thank you very much. I enjoyed your

presentation.

The next presenter is Stephanie Hamilton from Southern California Edison. Stephanie manages distributing energy resources at Edison. Southern California Edison is the second largest utility in California and has interconnected over 300 MWs of distributed energy resources to its power grid.

Previously, Stephanie held energy positions at some of the largest utilities in the U.S. in both natural gas and power in both their regulated and unregulated subsidiaries.

Ms. Hamilton holds a MBA and a BS in Mechanical Engineering. It doesn't say where, so I am sorry I can't tell you, and is widely published on energy and energy related issues.

Her latest book is the "Handbook of Micro Turbine Generators" and she has copies of that, and she will be autographing -- no, she doesn't, if you would like to get a copy.

She is a member of the Grid Wise Architecture Council. One of the comments I would like to make is the PIER Program has active collaborations with utilities, both in investor owned and municipal and both natural gas and electric utilities.

I think one thing that is very important is the utilities are really in contact with their customers. They are the ones who ultimately deliver energy supply to individuals. So, their customers are our clients also, the ratepayers that we are trying to provide value to. So, from that perspective, the PIER Program and utilities share a great commonality in really trying to look at the person who is finally using energy and how to supply them with the value of reliability and security that they need.

It is a pleasure for me to introduce Stephanie. The title of her talk is "Fuel Cell, a Utility Perspective".

MS. HAMILTON: Thank you. Can you hear me in the back? Good. This is what I'm going to talk to you about today. First I am going to give you a little commercial about Edison in case you are not one of those lucky people who live in our service territory. I want to make sure you know about us, and if you ever decide to come and live in Southern California and want us to call you so you can be one of our customers.

I'll give you a little historical

background on the programs that we have run in distributed energy resources. I'll talk about our current programs and then our desired future programs.

Our goal for the future programs are to help shape the potential for new capabilities and be knowledgeable and help bring this technology into maturity so it meets our customer's needs as well as support to our grid.

Okay, here is the commercial. We are the blue part there. We've got a pretty big footprint. It goes from the coast over to Arizona. The gray parts are Los Angeles County and San Diego area. The impressive thing I think for us these days is that we are growing at the rates of the 1950's and the 1960's.

We are adding 70,000 meters a year which is a lot of growth. Guess where it is going? It is not going west, it is all going east. We in our second year of an infrastructure rebuild in Southern California. We have put out about $7 to $9 billion, plans to build outside infrastructure.

We've embarked on things that really call on new technology. I am going to talk to you first just a few minutes about our manager of distribution engineering. I think he is a Renaissance Man in my name.

He said, you know, if we are going to put up this much infrastructure over the next five to seven years, let's think about not just putting back up the same things we've been doing for the last 100 years. Let's go about it in a different way. Let's think about what new technologies are out there. At the same time, we want to meet the reliability we need to do for our customers, but we need to do it cheaper, and we need to do it safer, and we need to do it with technology. So, we really focused on taking technologies and running with them.

If you don't know Edison's history, we come from innovation. The early years of our history is about innovation, moving the power from the hydro up in the Sierra's down to Los Angeles. That took different kinds of things, including patents that Edison brought in and new ways of doing things.

Two years ago the group that I am in was formed. It was called Engineering Advancement with the idea that we are going to take all these mavericks that are out there doing R & D and thinking about crazy things that we don't usually do in the utility business and pulling them in and trying to get them harnessed on looking at ways to bring in new technologies and use them to make us a stronger utility and also to meet our customer needs over the future.

I would also point to Edison's work in Rule 21. The CEC led this opportunity and we helped forge the Rule 21 that streamlines and standardize and makes it much more simply to interconnect to grids.

Edison is also a leader in using renewable sources. You can see here that we have made the target that has been set for many many years out. We are very proud of this. We are very lucky in our service territory because we have a lot of renewable energy, but we have made the most of it I think.

You are wondering why I am talking all about all this stuff when we are really here to talk about fuel cells. Okay, I think that is a good question. First I want to show you some of the historical work that I mentioned in the beginning that Edison started.

As Art talked about the Santa Clara

project, this was before I came back to Edison about six or eight years ago and also on Uni Cal. We've also worked very closely with our colleagues and friends from the University of California Irvine on fuel cell research.

Edison established the name of the National Fuel Cell Research Center at one of its plants that was eventually sold as part of the restructuring, but we transferred that name to UCI, and they have run with the ball and just made it a master place to be.

We've participated in a number of government and commercial planning activities in the past. Edison, along with the help of UCI and others, tested the first hybrid fuel cell. Nobody knew if this thing was going to work.

When I came back to the utility, they used to show me drawings of this thing, and it was my project, and I says, oh, 250 KWs, this couldn't be very big. Everytime I talked to UCI, they said, we don't know if that door is high enough to let this thing in. It turned out to be bubba, it was big. It proved the concept that you could actually integrate a fuel cell micro turbine. It was a very intriguing project.

Now here is the test demos and the goals and results. It did prove a concept. It showed that the concept would work. It is going to take a lot more engineering to make it commercially manufacturable and the kind of product that is going to be successful, but it did say it is not just an engineer's idea. It can be really done.

I'm going to talk about some things right now other than fuel cells. The reason I am going to do this is to let you know how interested Edison is in doing distributed generation, distributed energy resources.

You will see that number up there is $19 million funded by others. Our budget is very limited for doing R & D, so what we do is seek out others who have other similar kinds of interests in doing the work that we think we can add value to and has value for our grid and our customers.

We have tested for a long time micro turbines. Edison is probably the most experienced tester of micro turbines in the world. We believe another idea or project we have is communications and control. If you want to put distributed gen out there and make it an asset for both the customer and the grid, communications and control are going to be key to doing that.

We are looking at ways to take distributed energy resources and better optimize our grid. By that, I mean we could use DER as deferral. We could use it for adding robustness to our grid, to the reliability improvements, as well as potentially emergency operations where we need to keep our grid up.

We believe also that integrating DER with demand side management is going to prove to be a more reliable and a better solution than just two separately. With delta and solid oxide fuel cells, for example, looking at them for substation back up or replacement.

We are looking at ways to guide invertors so that they can provide interactive reactive power, reduction in hermonics, and the kinds of things that you want to bring to the invertor side question so that it does help the grid.

We believe customers with good high thermal loads can improve their efficiencies, and that makes a lot of sense. You have to have the right match. We believe that DG can help meet the power quality requirements if structured correctly. We believe that DG can be used for temporary operations and free fuel is wow, that is wonderful. We've got a lot of installations for free fuel use in our service territory.

With this slide, I want to show you an advantage for fuel cells. I am not going to go into the numbers, but you can see the emissions for 2003 versus what is proposed for 2007. My statement there, four out of five generators are fuel cells that can meet these emissions.

They asked us to talk about some of the incentives and programs that are out there for fuel cells. Probably you know these better than I do, but let's just look. There is exemptions for some of the interconnection for most of the fuel cells. Stand by and departing load charges.

We've got net metering tariff, which means you can run your meter backwards, which is cool. Then other self generation program provides for -- there is a number of different incentives based on the fuel you use for fuel cells.

This is the old program we have put out front, the 2006 program. What didn't change for fuel cells are the numbers you see there. What is missing in this chart is the first level, which is the PV.

I don't know why I decided to talk about this, but I always am challenged with it. This is a little bit about our grid. What you see is we are going from the high voltage to the lower voltage. What we are trying to do is use some kind of DG to help us with our lower voltage, our distribution system.

Our system is primarily 12 KV, which is pretty high voltage and 16 KV. So, my point in this guide is if you were going to use DG fuel cells or some type of DG to offset a deferral on a distribution system, you are going to have to have a lot of DG, two to three MWs of DG to do it.

We only need it maybe thirty days a year for four to six hours, so I don't know how that is going to fit in with your base loads. My point is, you need to think through these kinds of things if you are looking for this kind of market for DG.

I mentioned before this is one of our projects that we have been working with the Department of Energy as well as the California Energy Commission. This talks about the ability to add communications and control to DG at a very secure way, which is key to our business, and then be able to use it potentially by aggregating it, communications and control, to use it for both an asset for the customer and the utility. We are also working with the Energy Commission to integrate it with demand response.

I think Marianne and I think Nancy both made this point that you can see what you are up against in terms of we love the emissions here in the far right column, the big dark numbers. We love the heat rate, it is pretty close to central plant, which is that bottom line on the chart, but the capital cost is still -- it is just really too high to be competitive with some of the other choices.

Plus the technology needs I believe more proof to be confident it is going to be reliable for an electric utility.

We've been working with DOE out of Pittsburgh and Morgantown office, and the manager I mentioned before, he came up with this slide. He said $400 a KW for fuel cells, this includes balance and plant, could potentially revolutionize the utility industry. So, there is a mark in the sand for you to go for if you want to look for a number. That is our opinion.

If we put it at different points, we've done a lot of modeling to look at the value of distributed generation on our system. One thing we found that was interesting, that you know you need reactive power to move real power. So, if you can put some of these generation points close to where the demand is for the energy, then you can reduce the real power size you need out of the DG because you've got more power support there.

We think also that if you have a lot of it out there, you've got to think about how your fuel supply systems are going to be revamped to match it.

This is my wrap up. Our job as an electric utility is to balance quality, selection, and cost. We have to do this in everything we do. Edison is one of the most analytical companies I've ever worked for, but we do the numbers and we do them hard. We scrub them.

We do expect DG demand as I mentioned before are introduced, there is 300 MWs of DG interconnected to our grid, that may be the highest penetration of DG in the U.S. It is quite a bit, but we expect people to keep looking at that and how it would meet their needs.

I think if we can look for ways and this is the world according to Stephanie, to find ways to make the most of this assets for both the utility and the customer, there will be more value streams and we are more likely to find a home for all of it.

Thank you.

DR. SOINSKI: Do you have time for questions?

MS. HAMILTON: No hard ones, please.

MR. DEJONGUE: In many of these technologies, and not just solid oxide fuel cells but also others, but solid oxide particularly for this particular kind of distributed generation, there still is a significant need for risk or technical risk reduction. Now, somehow that doesn't seem to capture the interest, but it is actually perhaps the most important issue right now to the extent would say Southern California Edison put up funds maybe or namely funds, I am talking about a million dollars or something like that, to actually assist California Energy Commission and California to develop solid oxide fuel cell business to a meaningful level, you know.

A million here a million there, doesn't amount to much, so, much more is needed. I think Southern California has these kinds of resources.

MS. HAMILTON: Anybody have an answer to that question? You know, it is a good question, it is a fair question. Monies that we've used in the past for R & D primarily came through ratepayer funding. We still have some limited ratepayer funding.

What I would say is the group that you saw formed here, the Engineering Advancement, is a group that is highly focused on trying to move technologies along. They are doing it by trying to provide the technical advice that developers need to meet the needs for the technology of the customers and the grid.

Now I guess the other side of the question would be is if shareholders wanted to invest funds in technologies, and I guess some utilities do that. I don't know that we've done that. If we have, I am not aware of it. I think some other utilities do. For example, I won't name names, but some have invested in for example some of the fuel cell companies. We have not necessarily chosen to do that, not that we don't see that has promise, it is just we have decided other things to do.

I think we have made a real solid investment, though, with this group of people and using our internal funding to go after and try and shape the technology working with the Energy Commission and the Department of Energy, Oakridge National Lab, Pacific Northwest Lab, San Dias. You name it, anybody that wants to work with us that has a project, just call me. Here is my e-mail, e-mail me.

For example, we are working with two or three different providers of invertors. The idea there is to help them understand what capabilities that they bring out of that invertor. For example, increasing the VARS might be more advantageous to their invertor.

MR. SHANKER: This may be a question for both Stephanie and Marianne. There was a lot said about how expensive fuel cells are. What do the applications of that it would make sense to apply these two directly because if this was so expensive, why are photovoltaics going gang busters, even though they are more expensive than fuel cells? So, are there particular applications that fuel cells should be encouraged in?

MS. HAMILTON: You know, the DG that is on our grid is customer owned, it is not utility owned, so the customer makes the decision on what technologies to use. I know there are five fuel cell projects on our grid. It totals about 300 KWs I believe. The ones that I am most familiar with deal with waste fuel, so they can use thermal as well as the free fuel aspects of it. There are also projects that are funded by other third parties, not just the customer. Some of them tend to be demonstration projects.

Now the PV, again, that is the customer choice.

MR. SHANKER: Right, but the question is what is making customers choose PV over fuel cells if fuel cells are cheaper and there are rebates available. What is stopping them?

MS. HAMILTON: Uh --

DR. WU: The rebates (inaudible).

MR. SHANKER: There are rebates for fuel cells too, right?

DR. WU: (Inaudible).

MR. SHANKER: Right, so the question is fuel cells just need a bit more publicity, is that it, or -- because the rebates aren't all that great for PV. This is what I do all the time, selling PV, the economics of solar. They only make sense for certain kind of person, and that is someone who is already environmentally minded. So, what --

DR. WU: (Inaudible).

MR. SHANKER: Thank you.

MR. AMARNATH: I am Ammi Amarnath from KSON. Stephanie, you mentioned about the solid oxide fuel cell demonstration. During that time, there was a specific strategy on demonstrating fuel cells application. The question really is do you have a strategy moving forward between now and just like how the DOE showed the slides on the strategy. Do you have a strategy specifically for fuel cells, and maybe you can explain it in general for DG going forward in the next ten to fifteen years.

MS. HAMILTON: The projects that we do now, we go out and look for collaborators, we look for funding to do the projects. Like I said before, we are trying to focus on the balance of plant for DG because we think that is where the utility can add the most value.

We are limited in being to help with some of the things I think that Nancy brought up, the membranes, the stacks, that is probably not where we can contribute a lot, but with the invertor, we can show people what needs to be the requirements for integrating the grid, what are the beneficial aspects of it, and how they can shape their balance of plant to make the rest of their fuel cells stronger.

In terms of a strategy, we are open to projects. The difficulty with having a strategy is you have to have a lot of funding to carry out a strategy, and if you don't have the funding available to you, then you look and pick and choose the best projects you can to fit from a utility perspective.

For example, with EPRI, we are going to be testing a fuel cell in one of our substations as either a back up or a replacement for batteries.

So, that is one of the things we are doing. We are working with UCI with Jack Brouwer over there. He is doing the fuel cell stuff, all the hard stuff, and we are going to work with him on coming up with another third party on a market analysis. So, Edison will be aware of what the future is for fuel cells and where that cross over point may be when they come to that 400 KW. We would like to know that.

Otherwise on DG, again, we are looking at the aspects that integrate with the grid and have impact on our customers. So, that is our strategy.

MR. OVSHINSKY: Ben Ovshinsky from Obonics. I apologize if I am missed this, the 300 MWs DG that are grid connected break down into what kind of technologies? You mentioned a few hundred KWs of fuel cell, but I didn't catch the rest.

MS. HAMILTON: I have a chart, but I didn't bring it.

MR. OVSHINSKY: Is it diesel gen sets, or is that back up off --

MS. HAMILTON: That's back up, so we wouldn't include that. That would be stand by/stand alone power, but it is about half and half of IC engines, internal combustion engines and small turbines. We do have quite a bit of PV in terms of 1228 MWs, something like that. We could check that, but we do have a slide on that, I just didn't bring it this time, but the majority of it is internal engines, small turbines.

MR. OVSHINSKY: Thank you. A comment on maybe the advantages of PV over fuel cells. At this point, it seems to me they require fall less ancillary infrastructure, fuel, fuel handling, fuel distribution, fuel storage, especially if it is high gen, and no moving parts, and it is just cleaner "in every sense".

MS. HAMILTON: I think that might be a little easier so to put it.

DR. SOINSKI: Thank you very much. I could go on a commentary on the difference and advantages and disadvantages of fuel cells versus photovoltaics, but I will spare you of that since I have been involved intimately with both technologies over the last twenty years.

I believe we have a break. I left my agenda somewhere. We will be back at 11:20. Thank you.

(Whereupon, the workshop adjourned, to reconvene at 11:20 a.m. after the break.)

DR. SOINSKI: I sort of feel guilty about breaking up all these lively discussions, but I am really encouraged by the fact that people are talking. That is one of the things we are looking forward to. Hopefully, it will give us some of that wisdom also and share that with us.

One of the points about asking questions, if you don't come up to the mike, then your question will not necessarily get into the transcript, although if there is a question, one suggestion was that the speaker repeat the question or at least paraphrase the question and then answer it, and so that way it will be on it.

There is also multiple questions about are these presentations going to be made available. They will be posted I don't know, today or tomorrow. We have them on a CD, it is just a matter of getting them up on our website. So, that will be happening.

Now right now it says I am supposed to give an introduction to the Transportation Section, however, I didn't write it this morning. I am not a transportation person, I am a stationary person. Transportation is a new activity for the PIER Program, but it is not a new activity for the Energy Commission. We actually have a division that has done significant efforts in that area on very limited amounts of funds. You will hear about some of the work we've done from Ken Koyama.

We have three presentations, two before lunch, one after lunch. I'd like to introduce Charles Stone from Ballard Power Systems where he is the Vice President. I hope I am right, I just want to make sure I am on the right person. He is Vice President for Research and Development. His areas of expertise include unit cell component materials and designs for proton exchange membrane fuel cells. He leads a group of 80 scientists and engineers with unrivaled experience and expertise in fuel cell technology. As a member of the Executive Team, he is responsible for insuring the strategic alignment of technology development to product development and intellectual property.

He is an inventor of fifteen U.S. patents. That is pretty impressive related to fuel cell development in addition to his numerous publications and refereed international journals. He has a Ph.D. from the University of British Columbia in Organo Metallic Chemistry, which that is a very intriguing subject area.

Dr. Stone's talk is the Current Status

of PEM Technology Technical Challenges and Path Forward. It is our pleasure to have him here, and Dr. Stone.

DR. STONE: Thanks, Art. Just a couple of brief points in regards to the outline. I'll talk a little bit about very very high level commercialization strategy. I will talk about in somewhat more detail our technology road map. Again, this road map is very specific to the transportation application for PEM fuel cells, key technology objectives, technology advancement proof points. You know, where are we on the way to achieving the objectives of the overall road map. Then I'll say something about some demonstration fleets and fuel trials.

I'm going to put these all up at once. Basically, we start at the top here. What are some of the drivers, the key drivers, high level drivers for fuel cell vehicle commercialization? Which below that, firstly obviously, it is all about and Dr. Wu mentioned these critical characteristics already, performance, reliability, and cost.

The next layer below that from Ballard's perspective is the critical end product requirements like free star capability, durability, power density, and of course also cost.

The elements of the fuel cell vehicle are the fuel cell stack itself, and obviously I'll talk a lot about that. The other thing, of course, is the balance of plant. The reason that it is slightly italicized out there is Ballard used to have a very significant activity in development of balanced plant, but that is a business that was sold to ROAM Partners, Daimler Chrysler and Ford and is run out of (Indiscernible) in Germany. Then the electric drive is the other key subcomponent of the overall vehicle.

From Ballard's perspective from the stack and the electric drive, all of our activity is really driven by fundamental understanding. We spent a lot of time going through classical design adoration and that was very expensive, and it was also extremely slow.

About four or five years ago, we really started to invest very heavily in the fundamentals of the materials, the fundamentals of design, and the fundamentals of the end requirements, and I will show you some of that activity as I go through the presentation.

Then, of course, you need to bundle that into (Indiscernible) technology demonstrations, and we've been very fortunate working with our key customer partners in a variety of different fuel demonstrations. Again, I'll talk about those.

Ultimately, as we all realize, if any technology is going to be accepted by the end customer, there has to be an overall economic incentive for that acceptance.

This is our technology road map. There is a lot of detail here, but I will take you through it very quickly. It really parallels in many aspects. Certainly when we look at the 2010 objectives, a lot of the initiatives and excellent work that has been done by the Department of Energy, so that you will see that for cost, we are following the Department of Energy 2010 target of $30 per KWs.

These numbers in yellow describe where we are as proof points today and in the past based on the fuel cells stack in and of itself. It is very important to understand that these numbers in U.S. dollars per KW are extrapolated to a volume of 500,000 units so that the point I would make is that for example, for 2005, if we were to freeze the technology at that point and do no further advances in the technology of the stack and simply commercialize that technology at 500,000 units per year, the cost would be $73 U.S. dollars per KW.

The perspective here with these train lines all of them is to convince people that we have a trajectory to get to the ultimate target the DOE has defined for cost, and I'll give you some more specifics about that later.

From a durability perspective, again, the yellow dots show our actual capability. This is durability under actual automotive dynamic operating conditions. Durability is a very difficult thing to define because people don't mean the same things when they say durability.

What Ballard means when we say durability is this is based on a drive cycle that was dictated to us to key OEM customers, Daimler Chrysler and Ford. So, when we say 2,000 hours of durability, that is what we would expect to see from that technology if it was actually put into a fuel cell vehicle.

From a power density perspective, power

density is key for packaging. It is also very key for cost because the smaller the stack is, the smaller the number of components you are using. So, power density is a critical characteristic for us, and you will see that we have deviated somewhat from the DOE target here for a very specific reason. We've gone to a higher goal in 2010 for power density. That is because we think we are going to need that in order to achieve this goal of cost. We have quite a bit of 2.5 KWs per liter as opposed to the 2 KWs per liter that DOE has identified.

Freeze start, I won't go into. It is very critical. It is a very complex slide because we can't find a common message from our OEM customers whether -20 is good enough or -30 is required, so we basically included in our technology road map both elements that are being driven from the customer list.

What are some of the key technology and imperatives. For Ballard and perhaps arrogantly we believe for the industry, it is critical if we are going to stimulate commercialization that we demonstrate a viable stack technology.

If you look at the other subcomponents

of the fuel cell vehicle, they are much more engineering challenges. As Nancy said, there are some very specific challenges around fuel storage, on-board fuel storage, but I am personally excited by the advances that are being made in the 700 bar technology.

Daimler Chrysler, for example, is predicting 400 kilometers using the 700 bar compressed gas storage technology for their B class fuel cell vehicle which they will launch as the next technology demonstration based on the Ballard fuel cell stack.

I think everyone would recognize that the key technology barriers, the key technology elements reside within the stack. That is what the technology road map that Ballard has developed is meant to address, such that by 2010 we demonstrate the capability to meet the targets as defined by DOE to define our commercial viability point.

One of the other critical things obviously is the enhancement of strategic relationships. Ballard makes only one of the key components personally within our organization for the fuel cell. We make the gas to fusion electrode. All of the other components we either buy in or we have collaborate efforts with other suppliers.

It is really critical that those suppliers stay engaged, and they see the incentives to continue doing their own internal development. That they be encouraged by whatever means possible to try and break this price volume paradigm that we see in the mid range and the tens of thousands of vehicles.

At the moment, the materials are being classically priced. The membranes specifically, whereas we could stimulate, I believe, the commercial introduction of these materials if we could get some facilitated forward pricing. So, there is a lot of work going on with strategic relationships with suppliers to help that.

There is also a lot of work going on in the industry, not just in Ballard. In looking at what I would call emergent technologies, let me tell you why I call them emergent technologies. I don't believe that these technologies are necessary to achieve the objectives of 2010.

We believe that we can get to the 2010 objectives without necessarily having hydro-carbon membranes. There are other ways you can facilitate cost reduction using the existing chemistries which are more based on fluorinated chemistry.

Catalyst loading reduction is necessary, but, again, if you can improve significantly power density, do you need to get down to these loadings of what the industry is talking about, less than .3 milligrams per square centimeter platinum.

Metal plate technology would absolutely bring some advantages, but is it essential to get to 2010. Not necessarily, but as we look beyond 2010 to the more aggressive goals of 2015, these are the types of technologies that we are going to look to. So, we are looking to invest now, and we are hoping to encourage other players to start investing in these technologies so that they will be available in that time frame.

Key technology development directives. I'll rush through this because it is maybe a little bit too detailed. It is all about water management. If you can -- the person who manages or the company that manages to most effectively balance off the requirements and the management of the water that produces the by product of the fuel cell, will ultimately get to the best effective durable performing device, so there is a lot of work being done in that area.

From the perspective of driving fundamental understanding, there is a lot of work being done in accelerating design selection through improved tools. These are tools which allow you to understand more specifically structure prop to relationships between key components and the end design intent of the product.

Lastly and perhaps most critically from our perspective is engineered electrical catalyst layers, especially around the cathode. Again, I don't want to get into too much detail, I'll have to take questions later.

From a component perspective, we are spending a lot of money looking at composite membranes, and I will explain later why we believe that it is critical, as well as through partnerships looking at hydro carbon ionomers.

We already have a company in Lowell, Massachusetts that one of the only two companies in the world that develops a continuous gas to fusion liter that will facilitate the high volume manufacturing of membrane electrode assemblies, which is going to be necessary as you get into the tens of thousands of units per year.

I said I would talk about proof points. This is a very quick summary of the technology demonstration that Ballard communicated from the work in 2005. We were able to demonstrate in a single stack design free starts capability from 25 degree celsius in 90 seconds, and that was a very accelerated test. Those were 50 consecutive free starts, not something you would ever see in a real practical vehicle, but nevertheless, clearly demonstrating the capability of the technology.

I've already talked about how we measure durability in that same stack design that was free start capability at 2,000 hours, which is roughly 100,000 kilometers of performance depending on the actual cycle of the vehicle.

Lastly and very importantly, we were able to further reduce the cost, and this was driven predominantly by looking at reductions in the platinum loading. Platinum is perhaps the single most significant cost driver for the fuel cell stack. It is a commodity material which is an unbelievable price at the moment, over $1,000

U.S. per troy ounce. So, the effective use of that material in order to achieve reductions in the amount used without, and that is the critical point without impacting performance durability, that is the key driver.

We were able to achieve ten percent reduction in 2004 or 2005, having achieved already a 30 percent reduction in 2003 to 2004 without impacting durability or performance.

I said I would talk about accelerated tests and tools. This is a failure mechanism that we have identified, and the failure mechanism that is shown here is a function of loss and performance, high degradation and voltage under a variety of different conditions. All of these conditions are associated with start/stop, which is a critical characteristic of a required characteristic with fuel cell vehicle.

What we were able to initially our designs were showing significant degradation under those operational characteristics. We were able to show driven by fundamental understanding and material design, we were able to show significant improvement, not only through the some modifications to the operational conditions themselves, but through the material and through the design specific to the anode because this failure we identified was driven by the anode catalyst.

Again, I apologize that I can't go into more detail, but just to give you some examples of the types of work that is going on. Very important when you talk about strategy and achieving road map objectives that you have a key high level plan as to how you are going to do this, not only from a materials perspective but also from a process perspective.

Platinum loadings in the mid 90's were in the very very high range, 8 to 10 milligrams per square centimeter. Today Ballard's already demonstrated that we can process platinum loadings for fuel cells down to as lowest point 3 milligrams per square centimeter.

The problem is we can't do that without sacrificing performance and durability. From a processing perspective, we are looking at these things in parallel, so we have demonstrated a processing capability to get to this loading, we are not working on the structure of the electrode catalyst layer to recover the performance and resolve some of the durability elements that I just described in the last slide related to stop/start for the anode catalyst.

I said I would talk a little bit about the detailed fundamental understanding. Ballard identified a number of years ago a critical failure mechanism for the membrane component where the membrane was actually thinning. This is a scanning electro-micrograph, and this smooth area shows you a thin spot within a membrane that was actually operating in the fuel cell for roughly a thousand hours.

What happens ultimately, and, again, this was illustrated through a lot of work, to the fundamental cause of the failure is it eventually, the material thinned so much that the dynamic movement of water in and out of the fuel cell causes dimensional stresses in the XY plane, which ultimately leads to a physical break in this area where there was thinning.

So, the solution to that from Ballard's perspective, one of the solutions from our perspective was to minimize the stress of the hydration/dehydration, so minimize the movement of the membrane in the XY plane. We achieved that in very thin membranes, and think about thin equating to higher performance and lower cost, through the use of (indiscernible) structures where we take a very inexpensive micro porous material and add the functional part of the membrane to that micro porous material. That micro porous material restricts the ionomer from expanding in the XY plane. So, there is a very brief idea around fundamental understanding to dry failure analysis and using that understanding to drive solutions to those failures.

Cost reduction beyond materials is all about processing efficiency. We've been able to demonstrate, as I mentioned already, and these are just some photographs to show that, that you can go from a rolling good -- this is a gas to fusion electrode, through some hydrophobicity treatment, again, through a continuous process, and then finally the continuous process of adding the electro-catalyst to the GDL. This is what has already been demonstrated at our facility in Lowell, Massachusetts.

Durability is a very interesting thing. It is very very driven by operating conditions. These three pictures show different stack designs, but the fundamental unit cell is common to all these stack designs.

This is the product that was used in the busses in California and those in Europe. This is a stack design that is used in the Ford vehicles and the Ford Focus vehicles and the F-cell and the Daimler Chrysler vehicle.

This is a small stack based on the same unit cell technology, exactly the same technology that we are using for the forklift market. Now look at the difference in some of the dynamics, the pressure of operation is slightly different, but the key driver here to durability impact is how the stack is operated in the load demand cycle.

In busses, I'm defending this very quickly as a medium dynamic cycle, relative to a fast dynamic cycle for automotive, relative to what is a very slow dynamic cycle for forklift.

Now let's look at some of the data on durability. Remember exactly the same components, exactly the same unit cell design. What we are seeing on average in the bus programs is about 3,000 hours of durability.

In the automotive cycle, we are seeing

about 1,000 hours of durability. In forklift, which has this very slow dynamic response requirement, for the same design, we are seeing 10,000 hours. This is why I think it is very possible, even though a lot of our technology development is driven by automotive, we are seeing very clear use of that technology in other applications like forklifts and seeing significant advantages over what we are seeing in some of the other areas where the technology was originally developed.

There was very good activity and leverage to be gained from that technology initially developed for transportation and to other applications.

How can California help? Regulation will certainly will help drive growth in demonstration fleets that Carb Zev mandate has been very very critical, and companies like Ballard are very very grateful for that regulatory push.

Early adopters of fuel cell products obviously state-owned and state-run organizations taking the initiative to buy these vehicles and then test them out and provide the data back to the suppliers who will make the vehicles better.

State subsidy for green vehicles obviously is critical. Stimulating growth and investment for key component developers. There are some very good component developers in the State of California. I'll talk about some of those later.

I'm going to pass by this slide, it is bit of a PR slide as is that, and I will go to straight to my summary slide. From Ballard's perspective, it is obviously critical for us as a company, but we think critical for the industry is that these technology demonstration points that have really been set up and identified by DOE as a requirement proof point, that we are ready for commercialization. It is critical that these are met.

Reduced cycle time is also critical, and Ballard's driving of that by developing accelerated testing, leveraging fundamental understanding, and building very robust simulation and modeling capabilities so that some of the design can be done at a computer as opposed to a very slow, very cost intensive way of build, test, break, fix.

Fuel cell vehicle commercialization obviously will be assisted by regulation and subsidy. Fuel cells ultimately built they are going to be successful, have to offer that economic incentive to the end user.

Ballard thinks it is critical that we continue to leverage real life fuel demonstrations because that is where we get tremendous (indiscernible), which we can pull back into the lab to insure that the next designs are much more robust.

You know, health and lifestyle benefits of fuel cell technology, especially from our perspective, are going to be a great benefits to Californians as they are to many people around the world.

Thank you.

DR. SOINSKI: Any questions or comments?

DR. STONE: The presentation will be on the website, if anyone has any questions after getting a chance to read it in detail.

MR. BROUWER: Jack Brouwer from UC Irvine. I was intrigued by the durability performance, the rough durability performance you presented and the effects of dynamics on that durability.

What kind of fundamental mechanisms would you attribute that sort of dramatic increase in durability to?

DR. STONE: The differences in no failure mechanisms that we see are really going to identify, maybe not too specifically for proprietary reasons, but they are predominantly in the electro-catalyst, both the anode and the cathode due to things like carbon corrosion, for example, which is a pretty well known failure mechanism in the industry. It is understanding exactly what is causing the corrosion so you can switch it off.

Also we see a huge differences in membrane degradation in automotive applications versus the bus application, and we know it is because of the differences in the dynamic cycle and how the overall system can respond to things like the effects of humidification, for example, as a result of those very significant demands to move from idle to peak power in 1.5 seconds.

MR. BROUWER: Thank you.

MR. RASTLER: Dan Rastler with EPRI. You didn't cover it, but I was wondering if you could comment on the units you have operating in Japan, the EBARA units, there is 102 some units being deployed as residential applications. I was wondering if you could comment on how those are working, the durability of the membrane, and also what you might forecast as the likelihood of cost competitive systems for residential applications.

DR. STONE: Lots of parts to that question. Let me see if I can address them. I am going to rely on a comment that was set up for me by Dr. Wu in her presentation, and the Japanese market is very practical market to start looking at co-gen application because the grid price for electricity is very high. That provides a good even today somewhat of an economic -- there is a huge subsidy, but still an economic incentive to look at that market first.

Ballard has a very specific plan with our partners, EBARA Corporation to bring that cost down to a level beyond 2010, and that was one of my slides that I perused through unfortunately, beyond 2010 that will make it effective, cost competitive for the customer looking at both fuel and hot water relative to incumbent technology subsidy.

How are the existing products going? Well, last year Ballard was given the Japanese Government Award for having the best stack technology for its Mark 1030 product. Today those units in a school system are showing more than 10,000 hours of performance. Now that is a long way from 40,000 hours, but it is very likely that the next generation of product that we are working on today for the 2009 to 2010 time frame, that is directed towards achieving that 40,000 hour target.

DR. SOINSKI: Any other questions?

(No response.)

DR. SOINSKI: Thank you. As a chemist, it was a great pleasure for me to hear another chemist, especially talking about things like fundamental understanding, which I don't even get to think about anymore. I also think that Dr. Stone made a very nice link between Dr. Wu's comments about high value markets and the difference in durability and different applications. I thought that it was a very good linkage between the two.

The other thing that I liked was what I call the technology development continuum which is something I always ask for. We always ask for in proposals and very seldom see is like where does this particular research or where are we today with respect to where we have been and where we want to go because one of the things we have to look at is really as one our Commissioners used to say, how deep is the water and how wide is the river.

You know, you are looking at one little snapshot of it, but where do we really need to go, and that is an important perspective, and certainly I think that we got some good insights, I was very impressed with the whole road map concept.

The next speaker is Mr. Kevin Harris, the North American Development and Sales Director for Hydrogenics Corporation.

He is responsible for evaluating opportunities that accelerate the commercialization of fuel cell technology. These opportunities include supplier partnerships, ONM, and distribution partnering, market and child development, and sourcing of government funding.

He is actively involved in organizations that promote the use of hydrogen and fuel cells, including the California Fuel Cell Partnership, the California Stationary Fuel Cell Collaborative, West Start, Cal Start, the National Hydrogen Association, and the U.S. Fuel Cell Council.

Prior to his work at Hydrogenics, he worked at Cummings Engine Company as an Account Executive. He holds a Bachelor of Applied Science and Mechanical Engineering from the University of Waterloo and a MBA from the Richard Ivey School of Business at the University of Western Ontario.

It is a pleasure for me to introduce Mr. Harris for his talk "Marketing and Commercialization Challenges for PEM Fuel Cells".

MR. HARRIS: Great. Thank you for that introduction and thank you for the time and the opportunity to speak. I realize that I am the presentation before lunch, and trust me, I am very hungry myself, so I will try to get through this as quickly as I can.

Basically, I want to talk to you about hydrogenics for those of you who don't know much about hydrogenics. The commercialization challenges I believe in general that PEM fuel cell developer faces, how the CEC can help, and then some closing remarks.

We were established in 1995. We have three strategic business units. One is hydrogen generation refueling, which was really bolstered from our acquisition of Stewart Energy back in January of '05.

Power systems, which is what I will mostly be talking about today, which is fuel cell, power modules, and then we also have a test division where we sell test equipment to other fuel cell developers.

Our Headquarters is in Toronto. We have manufacturing in Vancouver and Belgium, and then offices in California. I am actually located in the Santa Clarita Valley. I am not sure if you know where Six Flags Magic Mountain is, but that is where we are located in the Los Angeles area. Germany and Japan are our other offices as well.

We are listed on the NASDQ Exchange and on the Toronto Stock Exchange. We have over 250 employees, and we are I guess amassing intellectual property assets as well.

This is a snapshot of fuel cell powered technology as far as Hydrogenics sees it. It is composed of the core stack itself, which in itself is composed of components, and the fuel cell power module, which includes the stack and the balance of plant items that are listed up on here.

Our products basically range from 8 to 6 KW power modules. They are basically hydrogen in, DC unregulated voltage out. We have options for some DC like 24, 36, 48, 72 volts and so on. We are also involved with creating what we call power packs, which takes the fuel cell power module and integrates it with hydrogen storage, energy storage, cooling module and so on that you basically have a plug and play unit.

These are some of the applications that we are involved with ranging from stationary back up in the lower left and auxiliary power unit on the upper right to lighter duty vehicles such as the forklift, neighborhood electric vehicles, John Deere is a big customer of ours, to the heavier duty application such as the delivery vans and busses that you see on there.

The commercialization challenge is this slide lists what I term as the classical challenges, which you have heard already a little bit about. One is cost, obviously the technology is very expensive now, especially with the units involved. We are not talking about thousands of units per year produced, we are more talking about dozens to hundreds of units.

Durability and reliability, and by the way, I kind of consider these in priority order. Durability is a challenge right now. We are in the about thousands of hours of durability for certain applications. We need to get to the tens of thousands of hours.

Hydrogen, I divide that into two areas. One is the storage of hydrogen itself and putting in enough hydrogen into a given space, and this is particularly important for automotive applications.

The infrastructure itself, again, for automotive where you need a network of infrastructure, refueling stations across the continent.

Codes and standards are still developing. Sometimes it takes a while to install let's say either a fuel cell application or a hydrogen refueling station because of the lack of codes and standards and having to deal with the authorities having jurisdiction and they don't have codes to basically cover their butts so to speak, so they have to be very conservative, and that takes time to get around.

Public outreach and education. I think it is a lot better now than it was five years ago, but there are still a lot of people who don't understand what a fuel cell is and don't understand the rate of commercialization.

These are more what I call marketing and sales types of challenges, but they are challenges nonetheless to commercialization. One is long sale cycles. Because we are dealing with technology that for the most part does not make economic sense against the incumbents, you are going to have to involve usually some sort of government source of funding be it municipal, state, or federal. Obtaining those funds takes a long time, so it is not rare to see sale cycles lasting one year or two year time.

Cost sharing requirements. A lot of these government funds do require a cost share. This is difficult for fuel cell companies who have a significant cash burn rate with the amount of R & D that they are doing. I think ourselves and many other fuel cell manufacturers are at the point where we have contributed a lot to cost sharing projects in the past, and now we are at the stage where can't afford to do a whole lot of that. So, that is a challenge in trying to commercialize the technology.

The OEM missing link. This is where you might have a technology developer like ourselves. You might have end users. You might have government funding, which is great and is useful for demonstration projects, but as far as commercialization is concerned, a lot of times, most times, I would argue that you would need an OEM that would take the fuel cell component, for example, integrate it into their system, and then use their market knowledge and market channels to penetrate the market. We still have an issue with OEMs and getting them on board.

Iterations on the technology are required. Unfortunately it is not like you can do one prototype and have all your problems solved and then go to market. The unfortunate situation with this technology is that you need to iterate on it. So, you might have to go three, four, five times before getting it right, and ultimately having a solution that is viable for the market.

Limited end user experience and unease about the technology. This is what I call the warm and fuzzy factor. Customers don't want to be the guinea pigs usually. They want to have a reference account, they want to know that someone else has used this technology. Maybe not even in the particular application that they are involved with, but somewhere. So, I would argue we need demonstration projects to tackle this issue.

What a lot of this boils down to really is cash burn, which is basically the amount of cash you spend over a fixed amount of time. The more time that is involved to commercialize, that is bad because at this stage in the game, fuel cell companies are going through cash, and likewise the iterations and so on are contributing to the amount of cash that you are burning.

It is all relative to the amount of cash that you have on hand and the ease of accessing funds from the capital markets or lack of ease.

How can the Energy Commission help? On cost, I have a few ideas. One is, you know, team up. If there is not significant amount of funds to do a project, then consider teaming up with other funding agencies or look at those markets that basically can afford the technology.

Actually the State of Hawaii has done I

would say a fairly good job of using Department of Defense funds since they are in a sense a military outposts of sorts. California I would argue also has a lot of military bases, and I think there is an opportunity there to piggy back the DOD funds that are out there.

Another example is back up power, which has been talked about already, but right now there is an economic case for fuel cell back up power as compared to back up power provided by batteries, cannot compete yet with internal combustion engines, but with batteries especially, if you are looking at a few hours of back up time, then it does make sense to look at fuel cells as an option.

I would also say look at novel approaches to reduce the amount of fuel cell power required. We are involved with a few projects where the power architecture is based on a battery-dominant system where a lot of the energy and power is derived from the batteries, but supplemental power and supplemental energy is provided by the fuel cell and the hydrogen storage.

You can minimize the size of the fuel

cell, that way minimize your cost of the overall product. That is obvious. What may not be obvious is the fact that, again, with these iterations, it is going to be very expensive to iterate on a system that is 200 or 300 KWs of fuel cell power, but to iterate on something that is 20 to 30 KWs of power is going to be a lot less costly, be it for the technology provider or for the government funding agency, whoever is funding those iterations is going to be cheaper.

The self generation program as it exists today is for continuous power, but one way to reduce the cost for the end user for commercial products today is to include back up power in that self generation program.

As far as durability and reliability are concerned, you cannot underestimate the value obtained from demonstrations and the field data from the demonstrations. That is really the only way we are going to get true data to help with durability and reliability. Another way also is to fund R & D work in these areas as well.

Hydrogen storage and infrastructure. Basically continue to fund R & D work in the area of hydrogen storage. The DOE is doing a good job of this.

Infrastructure. I think perhaps this is more on the side of the California Hydrogen Highway Program, but installing hydrogen stations for fleets that allow access to third parties and build infrastructure to match vehicle deployment. Again, the Hydrogen Highway is already doing these things.

Codes and standards, I am not an expert in this field, but one example that would help the industry is on the refueling side of things where we need codes established for using composite tanks for ground storage.

Right now basically what is in the code is metal tanks. Using composite tanks will reduce the footprint and possibly even the cost of this ground storage. It is the American Society of Mechanical Engineers that is basically the authority having jurisdiction if you will, so anyone can help in expediting to do this, that would be a key thing.

Public education and outreach. I would say continue to have demonstration of near commercial products, and I will get into what I mean on the near commercial side of things in a few slides.

I would endorse early fuel cell markets such as back up power and forklifts. We've seen the GPS Systems in the military used for years, and its introduction into civilian use, I see it as being fairly easy to do. I think that people, even though they might not need a forklift, if they know the fuel cell technology is widespread in that particular industry, that will give them the warm and fuzzy feeling if you will to purchase the fuel cell for whatever application they need, be it a stationary power unit for a commercial application or residential or what not.

I would also propose consideration of the Hydrogen Village Concept, which is a concept being manifested in Toronto, Ontario to link up with the Hydrogen Highway Initiative. Basically what this is, is taking a location whereby different types of fuel cell technologies can reside in one location basically or in a general area.

It would not only include transportation application such as light duty cars and busses, but it would include stationary, it would include different ways of making hydrogen, either through electrolysis or natural gas, it would include off road applications in addition to on road. That way you have basically a micro cosmo of the hydrogen economy in a single spot, which I think would bode very well for public education.

This picture basically shows some of the things that are involved with the Hydrogen Village. There is wind turbines, there is normal grid electricity, there is hydro power, you see there is a natural gas pipeline coming along the upper left hand side there, and then some of the applications including stationary power, busses, forklifts, and vans, and so on.

As far as the marketing and sales challenges, as far as long sale cycles, I suppose one way to get around that is have funds that are appropriated and allocated and issue our RFP's or RFQ's, request for quotations, requests for proposals, with these preapproved funds. That way there is no question or there is less of a risk of that money falling through and having the sale cycle grow even longer.

Cost sharing requirements. Well, the easy answer is to fully fund projects, but maybe more of a realistic answer is to combine funding sources with other funding agencies to establish full funded projects. I think in California there is that opportunity with some of the air quality management districts, the Air Resources Board and so on.

As far as the OEM missing link is concerned, basically you can show the OEM's that there is an interest in this technology, provide a poll by participating in a demonstration or by committing to purchase a "X" amount of units, whatever those units may be. If all technical and commercial requirements are met, that means it satisfies your needs and there is little risk in proceeding with commercial order of some quantity.

If not all the commercial and technical requirements are met, you just don't go ahead, and there is no risk.

Iteration of the technology required. I don't think you can get around the fact that you have to do iterations, but funding demonstrations can accelerate the rate of iterations, and that ultimately will help commercialization.

Limited end user experience will basically be a user of the technology, become a reference account, and that will help in soothing customer's hesitations with the technology.

In summary, you know, what we would really like to see is fully funded projects or organize a set of funding agencies. That is a large part of what I do is looking at different funding organizations and getting them together. It is a bit like herding cats, and that can be done by another entity, that would save the technology company a lot of time.

I would also say to purchase a commercialized fuel cell product and how do you know when a product is commercialized. I think there is a few things. One is there is established price, there is established specification, and there is established warranty.

Another way to really determine if something is a commercial product is to see how many companies in total there are offering certain product in that application. In back up power, for example, we have our company with APC or American Power Conversion that has a back up power unit. Plug Power, IDETEC, Rely On. Likewise for the forklifts, we are seeing not uncommon like ourselves, but Ballard with Selex and Ballard with General Hydrogen, Nuvair is also involved with forklifts, Proton Motor in Europe is another one. I would say those are two viable applications to consider as commercial.

Consider the path of commercialization in funding decisions. Include funding that will lead to an ultimate goal. If your ultimate goal is continuous power, that is great, but to necessarily fund something that is still a few years or maybe even a decade away, at least as far as PEM technology is concerned in my opinion, that might not be the best utilization of funds.

Think about what the path is to commercialization, what will happen first that will help ultimately your goal. So, funding back up power is a first step towards continuous power or funding off road mobility such as forklifts that will facilitate the commercialization of on road mobility.

Analogously with hydrogen, look at lower cost hydrogen production from natural gas that will ultimately lead to hydrogen from electrolytic processes derived from renewable energy. One thing to note here is hydrogen from natural gas, as far as greenhouse gas emissions are concerned, are still depending on which study you look at, are 20 to 40 percent less greenhouse gas emissions of the total life cycle analysis when using a fuel cell vehicle as compared to a gasoline engine, or it is still less than using natural gas directly in internal combustion engines as well. So, it is something to thing about.

This is my second to last slide. Again, include back up power applications in the self generation program. I talked about this a little bit in the previous slide, use the funds wisely. I don't see a lot of sense in funding a demonstration that is a decade away, but I would propose that you could fund R & D work in this area. I think there is a lot less risk in doing something at the laboratory scale.

Last but not least, you know, fund demonstrations that are near commercial, and this may warrant consideration of novel power architecture, such as a lower cost fuel cell battery dominant hybrid system. Here pictured is a bus that is being developed right now that is the 35 foot bus that holds the same amount as a 40 foot bus, but uses about 32 KWs of fuel cell power. You can imagine how much cheaper a bus like this would cost.

Our actual president is over on the far corner if you want to talk to Dale Hill afterwards, but that summarizes my discussions. I thank you for your time.

DR. SOINSKI: Are we going to have any questions before lunch?

MR. HARRIS: I saw one over there.

MR. OVSHINSKY: Do you guys consider yourselves an OEM?

MR. HARRIS: No.

MR. OVSHINSKY: Who would be those?

MR. HARRIS: APC would be an original equipment manufacturer. Dale Hill of Mobile Energy Solutions is a bus manufacturer. John Deere, for example.

DR. SOINSKI: I really appreciate your comments about funding things wisely and the types of demonstrations to do that. I think there is very valuable perspective for not only the PIER Program to have, but also organizations like the California Stationary Fuel Cell Collaborative.

On the back of your agenda, on the back of the some of the copies of the agenda, there is a list of nearby restaurants if you don't know the area. My personal favorite right now, which is subject to change, is actually at the Secretary of State Building's cafeteria on the second floor of the Secretary of State Building, which is about a little less than two blocks away. I like it because it's got large windows and you can see out. I like to see outside.

It is a beautiful sunny day in California. Enjoy, and we will see you back here at 1:25.

(Whereupon, at 12:25 p.m., the workshop was adjourned, to reconvene at 1:25 p.m. this same day.)

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AFTERNOON SESSION

1:32 p.m.

DR. SOINSKI: This is a clean up of transportation fuel cell portion by Ken Koyama. I mentioned that the Energy Commission has had transportation related activities for quite an amount of time. I have experience in infrastructure for methanol and alternative fuels, a lot of expertise, and over the last few months, I have grabbed two of the people who worked in transportation for the PIER Program. One is Jennifer Allen and the other is Ken Koyama, who is worked since day one at the Energy Commission managing emerging energy technologies.

He is a supervisor in what is known as the Energy Generation Research Office, EGRO, which includes renewables and advance of fossil fuel technologies. He has a Bachelor's Degree from UC Davis and a Masters from UCLA, and today he is giving a presentation on the National and International Fuel Cell Bus Programs.

MR. KOYAMA: Thank you, Art. I actually thought coming over to this office was my idea. Today I am putting back my old hat on transportation activities and what I am going to do is talk a little bit about the Fuel Cell Bus Program that I was the team lead for it for the Fuel Cell Partnership for the past five years.

I want to talk a little bit about what our goals are for the transportation energy here in California. I'll talk a little bit about our current demonstration of fuel cell busses and give some interim results, partial results, of the data that we've come out with and end up with what our research needs are going to be for fuel celled busses to make these things commercialized in the future.

Our goal is to increase non-petroleum fuel cell by 20 percent by 2020 to 20 percent. We want to increase non-petroleum fuel use to 20 percent by 2020, that is what I want to say. This was adopted back in 2003 in our Integrated Energy Policy Report, and we all wonder why we are using so much gasoline. Well, now it just so happens I actually need my sport utility vehicle for the once or twice I need to go up to the snow.

You've seen variations of this graph this morning. What this basically showing is that our demand for transportation energy is increasing, and it appears to be increasing where as our ability to provide fuels has stayed level and will probably not increase that much. So, we have to do one of three things.

We have to import more fuels into California. We have to reduce our petroleum use, and we have to find substitutes. So, one of the strategies, of course, is to find every nook and cranny of various petroleum reduction possibilities, one of which, of course is with busses.

There are 56,000 busses in California, 8,000 in transit agencies. We've done a pretty good job of finding alternative fuel uses in these busses. We've increased our population of non-petroleum busses to over 4,000. Most of these are natural gas busses, they are populated in both transit and school busses, but they are still pretty large and sizeable and available markets for more alternative fuel busses still available in California.

Busses do use a significant portion of diesel use in the state. Of the three billion gallons of diesel that is used in California, about a quarter as my estimate goes towards transit busses or diesel busses.

Of course, then the Hydrogen Highway, they've targeted busses as a potential early introduction of fuel cell or hydrogen vehicles. Heavy duty vehicles, they generally need to be busses because that appears to be the most near term potential for markets for fuel cell and hydrogen applications in the heavy duty market.

The first phase, our goal is to get ten busses operating in the state. The first phase is generally around the 2010 time frame, although they decided not to determine when these phases will occur, but once we hit the ten, then we have completed the first phase I guess.

The second phase is hundred, and Phase 3 300, so if we give some arbitrary time lines, we can say Phase 2 is 2015 and Phase 3 2020. Well, there is going to be a lot of work that needs to happen before we even get to those numbers.

We started the demonstration program under the partnership. We've started it back in 2000, and last year our first busses became operational at the Santa Clara Valley Transportation Authority. They have now three busses in Revenue Service. They have been used at various outreach events, but generally speaking, they are in -- they are used in regular everyday revenue service. They have found a variety routes that these busses can travel on.

Because it has been about a year, a little over a year for the operation of these busses, we were able to gather some data. This is what I want to present to you on the next couple of slides. As of October 2005, we have accumulated about 25,000 miles on those three trans busses. The average fuel economy is about three miles per KG of hydrogen or about 3.45 miles per diesel gallon equivalent.

We have found that these busses, and these are prototype busses, so you can't expect that these busses will operate the same way as diesel busses do, but the average maintenance costs are significantly more than diesel busses. There is a picture of the report that you can download from the National Renewable Energy Lab website.

On a monthly basis you can see that the fuel cell bus and the diesel bus, the diesel busses' fuel economy is in blue, the fuel cell busses are in green. We stay pretty consistently below diesel bus fuel economy.

Other data points, the top graph shows that we are paying significantly more for fuel than we would for a diesel bus. Valley Transit Authority has to pay about between $8 to $10 a KG for hydrogen. A KG of hydrogen is about equivalent to a gasoline gallon. You can see even with our really expensive gasoline now, we are paying for the hydrogen than current petroleum fuels.

Other data points, the transit agencies use miles between road call as a determinant of their reliability. So, for fuel cell busses, for the three fuel cell busses at VTA, they go on average about 1,000 miles between road calls. So, when a road call happens, they have to shut the bus down, they have to get a tow truck to bring the bus back in, regardless of what the reason is, and fix the problem.

With the diesel busses -- by the way, not all these road calls are fuel cell related. There are other issues, blown tire, that kind of stuff, but that is not distinguished in this data.

For diesel busses, that averages at a 11,000 miles between road calls, so we are about ten times under what diesel reliability is.

Maintenance costs. We talked about that earlier.

Monthly average miles driven. The fuel cell bus averages about 700 miles in a month whereas the diesel busses go about 4,000 miles in a month. This is an average miles driven. A lot of that has to do with the warranty issues. The fuel cell manufacturer limits the number of miles or hours of operation that a fuel cell bus can go, whereas diesel busses, they can operate 20 hours in a day depending upon the operation of the transit agencies.

In all these cases, though, we can see that there is significant improvements that we still have to try to meet to get to diesel performance levels. What we want to do is improve the technology so we can approach diesel performance to the maximum that we can.

The other demonstration side of AC Transit, and they use a different type of fuel cell bus. This is a hybrid configuration that they've got these busses. Previous busses were all run on the fuel cell itself in transient cycles, whereas the AC Transit and the Sunline busses that I will show you next have a hybrid configuration.

These busses are expected to operate 100 to 150 miles per day. Again, the miles are limited because of warranties of the fuel cell supplier. They began operation officially on March 13, my wife's birthday so I couldn't go. That was in conjunction with the National Hydrogen Association Conference. Just preliminary numbers show that they get about eight miles per diesel gallon equivalent. So, it is a significant improvement than what you saw in the Sunline Operation. We think that the hybrid configuration has probably a lot more advantages with regard to efficiency than the fuel cell only bus.

The President came to the Fuel Cell Partnership in April, and the fellow on the left works for AC Transit, those of you who know who Jamie is, he is a very passionate person, a very willing to talk about fuel cell busses, telling the President what a wonderful bus these are. They need more money, but I actually know Jamie, and I know Jamie very well. This guy is a die hard liberal, and I know he wanted to tell Mr. President we've got to get out of Iraq, you've got to do something about global climate change, fix social security, etc. etc. Fortunately his son told him you've got to stick to the topic, Dad.

The President later in his speech referred to Jamie as the bus man, so as you know, President Bush has these nicknames for these guys, so Jamie now is forever known as The Bus Man.

At Sunline, they have one fuel cell bus. This is also the same configuration as the AC Transit bus. They officially unveiled on November 16. I am on the left side here, this is the first time I was ever on a ribbon cutting thing. It was a lot of fun and got the first ride on this fuel cell bus, and it was actually terrific.

Palm Springs, as you know, is very warm. These operate pretty much 24/7, well, I shouldn't say 24/7. Whenever these busses are operating, they are on air conditioning, so we were very interested in seeing what the fuel economy is of these busses. It turns out that it is not bad. They are averaging over seven miles per gasoline gallon equivalent. Again, you know, if you translate that to diesel gallon equivalent, you know, it is still on the six and a half miles per gallon diesel. That is still better than what the average diesel fuel efficiency is.

They operate these vehicles eight hours a day. They go about 123 miles on their typical route. They believe they can do a sixteen hour day with a 230 mile route, and the current odometer right now is at 14,000 miles.

There are other demonstrations, the most recent additions to our fuel cell bus fleet occurred in China. This is in anticipation of the 2008 Olympics, so they persuaded Daimler-Chrysler and EcoBus to produce three more fuel cell busses for China. These are now currently I believe, they may have gone into operation and they are getting them ready for the Olympics.

The CUTE Program is the European Bus Program, the Fuel Cell Bus Program. CUTE stands for Clean Urban Transit for Europe. This is a group of they originally had ten sites. This is the CUTE ECTOS, and there is one other, but don't ask me what the nicknames are for, but they had at one point thirty fuel cell busses operating. They have now reduced that number. A couple of sites have dropped off. They now have seven sites operating in Europe. They have gotten additional funding from the European Commission for one more year of operation.

The ECO Bus is in Australia, they've got three busses, the same configuration as the CUTE and China busses from Eco Bus. This is again, I am using a fuel cell only configuration. The Japanese had an earlier demonstration with Heno Toyota. These busses were operated for a limited period of time, and I believe they are not operating at this point, although there is some talk about trying to get them back up and operating.

Just to get you a sample fuel economy dated from these other sites, and this really stretched my math abilities because I had to convert kilometers per kilograms into miles per diesel gallon equivalent. This is give or take, but you can see that there are some significant differences. The Japanese bus is a hybrid configuration. Sunline's busses are a hybrid configuration, and the AC Transit bus is a hybrid configuration.

They appear to have consistently better fuel economy than that of fuel cell only bus. This is in comparison to the average diesel transit bus of 3.5 miles per diesel gallon equivalent.

I don't know, this kind of gives me a pretty strong conclusion that in order to gather the most efficiency on these fuel cell busses, we will probably need to look at hybrid configurations.

There are more busses to come. There are forty operating now. BC Transit they would like to get I heard up to twenty fuel cell busses, and this is in anticipation of their Winter Olympic Games in 2010.

Dallas is also putting together bus specs for a fuel cell bus. In Las Vegas, which already has some hydrogen fueling stations and a fuel cell demonstration going on with light duty vehicles, they were also talking about adding transit busses to their fleet. There are probably many more others that I haven't included in this slide.

The research needs. I don't expect for you to see these tables or read these tables one by one. The point of this table is we have to make progress. Each step, each generation that we look at has to show improvement because we are not meeting what transit agencies expect as far as their diesel busses are concerned. We expect their diesel transit busses to go 350 to 400 miles per day, while we are limited to 180 maybe 200 miles, so that it is significantly less than what transit agencies need.

Each step, we want to see performance levels increase, but at the same time, we need to see the cost of these busses decrease. So, by the time we get to Generation 3, and this by the way was developed with the bus team at the Fuel Cell Partnership and the Federal Transit Administration, by the Generation 3, we want to get to the point where we are only double the cost of transit busses.

Generation 3, of course, is not the end. We have to continue with Generation 4, and at each level, we have to get down to a point where we are getting at least competitive with diesel busses. So, we have these performance targets, we want to see the technology improve in these areas, and we believe that these are where the research needs are really important.

That is the end of my presentation. Thank you very much.

DR. SOINSKI: Comments? (Inaudible).

I think one of the interesting things that Ken brought up is that I guess we are at Generation 2. Generation 3 will not be good enough, and after that, there has to be Generation 4. What they are competing against is the diesel.

Does anybody have any comments? This is now the opportunity for people who were not invited to speak to give their perspective on technology development and technology gains related to fuel cells for transportation applications.

Lutgard, you are a stationary guy.

MR. DEJONGUE: (Inaudible).

DR. SOINSKI: Actually, the materials side.

MR. DEJONGUE: I want to get back to the question of durability, particularly perhaps in the context of this best performance. It seems to be needing service every thousand miles.

One of the issues of course in durability and reliability is what are the statistics of these lifetimes. Are these statistics are very broad. You can have one cell that lasts 5,000 hours, but the spread is very wide, and that would imply rather important notifications of manufacturing and whatever else may be the problem.

I think to test these things on demonstration level is a very expensive test tube, so I want to see where you sort of drawn the line where it starts to make sense to maybe have a more significant growth are in the laboratory scale effort before launching into the demonstration hardware with millions of dollars. Who collects statistics on the full scale demonstration is a little bit questionable in my view.

MR. KOYAMA: I just want to say we heard earlier this morning that one of the goals is to have reliability or fuel cell operations of 4,000 hours. That turns out to be about one year of bus operations for a typical transit bus, so we are clearly going to have to have something that even exceeds that level of operation for the bus side.

MR. HARRIS: In a traditional way of viewing things where a diesel engine might last 30,000 or 40,000 hours, it is I guess a difficult proposition to do a demonstration where the fuel cell might only last a tenth or less than that amount. However, another thing you have to think about, as I was talking about before, the different architectures that are coming out, like the plug-in hybrid and the battery dominant, such that now you are dealing with potentially a much smaller fuel cell where you can actually afford to change it out more often.

Now 4,000 hours of operation may be or in that architecture may be only 10,000 hours is required because you are using a much smaller fuel cell, and the economics makes sense because to replace or to refurbish that stack is much less costly.

I mean it is a difficult question answered to say where exactly do you draw the line. I think we are now getting into the thousands and reaching potentially the 10,000 hour mark, which reminds me of a point that I forgot to make during the meeting. As you saw some of the effects of dynamic loading on the fuel cell, how that has an effect on life, well, again, if you entertain a different type of power architecture where the battery or the ultra-caps or whatever the energy surge might be, is taking a lot of those dynamic loadings, then the fuel cell is left to a more gentle duty cycle and then the amount of hours of lifetime will increase.

It is kind of a few variables that are making it difficult to pinpoint a specific, okay, once we know the fuel cells can last 6,000 hours, then we should go to demonstration phase. Anything before that, we should try to resolve in the lab first.

I know that doesn't directly answer your questions. I know right now under the battery dominant type of architecture that we are in the range of doing demonstrations in my opinion.

MR. DEJONGUE: Can I ask a follow up question? It is the same question, but probably more pointedly. What is the distribution of their lifetime?

MR. HARRIS: I think from a statistical point of view, it is difficult to say. We are dealing with a data set that is in the hundred, hundred plus mark. The other thing to realize that makes it difficult to answer is that one of the major things we are trying to do is reduce cost, so in doing redesign work to take out cost, you essentially start from zero your durability because you are using different balance of plants, components, so we were able to obtain over 7,000 hours of durability.

Now that we have done a redesign, I think it would be false to say that we are still at 7,000 hours because we are essentially starting over again. Are you asking me for the standard deviation, and I guess I am going to take the answer and say I am more the sales and marketing guy. I really don't know what the standard deviation is on that. I would assume that it is a few hundred hours or so, that is my guess.

DR. SOINSKI: Does anybody have a comment on this topic before we go on (inaudible)?

MR. ADDISON: I'll summarize from here (inaudible).

MR. OVSHINSKY: Can I add -- increase diesel regs (inaudible)?

MR. KOYAMA: You know, all those regulations are important drivers to see the evolution of these technologies improve. One of the problems we have is that our curve for meeting diesel transit bus operations and costs is that we are such -- it is such a steep curve at this point that any of those advantages, you know, takes us up incrementally, but by 2010, we may not get to the point where we are still competitive with diesel engines.

I mentioned that we had these performance targets by 2010, we hope to reduce the costs of these busses down to about four times the cost of a diesel bus, which means it will be still over a million dollars, and we still aren't sure how we are going to reduce the fuel cost of hydrogens. It appears to be coming at a plateau of about $8 per kilogram.

Unless diesel prices are significantly increased and unless people show that you can't meet the new emission standards with diesel engines, you know, we are going to have a very difficult time going much beyond demonstrations in 2010 in my opinion.

MR. HARRIS: I would basically agree with that with the exception of, again, what is going on with hybrids today in vehicles and plug in hybrids and how that can spill over into the bus application. Again, I am repeating myself, but using battery dominant in a smaller fuel cell, potentially there is a chance by 2010 to have a bus that is not an order of magnitude out, but within two or three times out what may be a C and G bus might cost.

I think that 2010 will be more -- I am

excited about 2010 in light of what is going to happen with the forklift and the back up power area. I think that will be the tell tale sign as far as progress in the fuel cell industry.

MR. SKAGGS: Hi, this question is for Ken. Ken, this is a two parter. First, I was interested in the cost to operate the O and M on these busses. Can you tell me what the source of the hydrogen was and whether that had an effect or how it may have effected the cost per mile? The second part is the maintenance cost. Were you able to separate out the hydrogen related maintenance as opposed to flat tires and etc.?

MR. KOYAMA: The first question about the hydrogen source, that is from a commercial vendor. Air Products provided the hydrogen, they also built a station at VTA. They put in a substantial amount of money to put into that station, but they are not giving us any discounts on the fuel.

The hydrogen does come from -- there are several hydrogen production facilities in California on which they have built (indiscernible) and sent it over to VTA.

The second question with regard to how

if the statistics showed the differences between the maintenance costs of flat tires versus that of fuel cell related activities. I have to refer you to report that ENRAIL produced. They may have differentiated those things, they certainly got that information and I don't recall seeing a summary table of that, but that report should provide you with that data.

DR. SOINSKI: Anything else?

(No response.)

DR. SOINSKI: With that, I thank Kenneth. (Inaudible).

MR. REMICK: Hi, I am Bob Remick, and I bet you no more than five or six of you know who I am. I am currently the Executive Director of the Colorado Fuel Cell Center, and it took me three months to learn to say Colorado and not California.

I have started working in stationary fuel cells in 1978, working at the old institute of gas technology. I have worked in phosphoric acid fuel cells and molten carbonate fuel cells, and solid oxide fuel cells. I have 43 publications, which is not a lot and ten patents in the energy field, which is not a lot either.

I've been asked to come here by Bob and share the stationary fuel cell section.

Having started out working professionally in 1978 after teaching school for ten years, at the Institute of Gas Technology, I would say that the gas industry would like to claim that in 1958, we started this stationary fuel cell program with research to develop what was then going to be the all gas house.

It was the gas industry's answer to the electric industry's all electric house. So, where electricity, they wanted you to do all your heating with electricity, the gas industry decided we will build a fuel cell, and you don't need an electric line, you can just bring the gas in and make your own electricity.

The American Gas Association funded a program known as TARGET from the middle 60's to the middle 70's, it was ten years long, and it was one of the few instances where the AGA actually funded a lot of research to look at the fuel cell, the stationary fuel cell on the end of the gas line.

There were two aspects of that. One was the residential fuel cell, which of course is continued to be the holy grail for the gas industry. The other was a larger commercial scale fuel cell for apartment buildings and small businesses.

That target program, the prime contractor on that program was United Technologies Corporation, and the Target Program identified three fuel cell technologies.

The first and closest to commercialization they felt was phosphoric acid fuel cell. So, that became their first generation fuel cell.

The second generation fuel cell was the molten carbonate and was a little farther down the line. The third generation of fuel cell would be the solid oxide fuel cell which they felt would take the longest to develop as a commercial product.

The gas industry continued to fund a lot of research and a lot of demonstrations through the 80's and into the 90's, and a lot of the research being done by the Department of the Energy, by that time the AGA was out of business, and it was all Department of Energy, a lot of the cost sharing was done by gas industry. San Diego

Gas and Electric, for example, has done some cost sharing and demonstrating.

Technologies which we are still many years away from commercialization. However, when the gas industry was unbundled and separated into producers, the pipeline transporters, and the local distribution companies for distributing, and that the local distribution companies were still under the PUC control, it became very difficult for the gas industry to take money and put it into long term research.

It was very difficult for the utilities to do that unless they went to the PUC's and got permission to add a little bit of money onto everybody's gas bill to do research. Most of that ended up being focused on distribution technologies, how do I distribute gas more efficiently, lower cost, and more safely.

It was still possible for a lot of the investor companies, investment sides of the gas companies to put money into fuel cell research and demonstration, but they became as most investment companies are today, a very short termed focus. They like to see return on their investment in six months or twelve months. So, money for doing research into long term technologies which may take five to seven years before commercial products were available, kind of stopped as far as the gas industry was concerned after it was unbundled. It was about the year 2000.

That is where we stand now with the stationary fuel cell technology. Virtually all of the research and development is coming from the department of energy. All the demonstration money is coming from investors primarily in the fuel cell companies themselves.

I would like to now go back and start. You will notice that our program is organized into Generation 1, Generation 2, Generation 3, phosphoric acid, molten carbonate, and solid oxide fuel cells. We've invited Mike Binder, who is one of the foremost authorities on phosphoric acid fuel cell demonstrations to come.

This goes on for another ten minutes. Essentially, I think many of you may know Mike. Mike ran the (Indiscernible) Demonstration Program in phosphoric acid. He has a long list of other accomplishments that he has done. He has also been a recent Chairman of the Fuel Cell Seminar.

He now operated Mike Binder and

Associates a consulting firm. He is retired from the Army, and we are honored to have him today to talk to us about his knowledge of phosphoric acid fuel cells.

Thank you, Mike.

MR. BINDER: Thank you, Bob. Everybody knows there is an oil shortage in this country and kind of wondering why, well, people just don't check it. You know, if it is an automotive odor, you are supposed to check the oil every once in awhile and see how much you've got left. It is really hard to do as a country because the oil is in places like Texas and Oklahoma and way up in Alaska, and all of the dipsticks are in Washington D.C.

I started the U.S. Army Construction Stationary Research Lab Fuel Cell Program back in about 1991. I worked on it until a year ago today where I took an early retirement from the government and went on to my own consulting company.

I have dealt with stationary applications in phosphoric acid, proton exchange membrane, molten carbonate, and solid oxide through the various programs that I've run, I've been responsible for the installation of well over 400 fuel cells world wide.

The program started it off with the phosphoric acid program sponsored through lobby efforts by the Gas Association as Bob said back in 1993.

Let me just go a little bit of a background about how these things works. I think most of you know about fuel cells. Phosphoric acid fuel cell basically it is like a battery of a anode, cathode and some kind of an electrode in between, in this case phosphoric acid.

Hydrogen is delivered to the anode, through a catalytic reaction the hydrogen splits into protons and electrons, the protons migrate across the electrolyte into the cathode, where the combine with the electrons that have gone out through an external circuit, and with the oxygen taken from air to produce water, heat, and DC electricity.

Typically, there are some hydrogen fuel cells that we just take DC power out of for certain applications, but in general we don't get the hydrogen as hydrogen itself. In stationary application, it comes from some other fuel, particularly natural gas is the most common, ADG, aerobic digester gas is also common, propane, and more and more moving towards other fuels as well that we can reform to get the hydrogen.

That goes through a fuel processor where we end up with a fuel rich stream, and then the DC power out goes through some kind of a power conditioner generally to give us AC or regulated DC power out. The heat we have can be rejected or it can be recovered in a co-generation scheme and be used for useful heat as well.

In the U.S. and essentially world wide, the major PFC companies are two, United Technologies Corporation, which I think everybody knows under the various guises as (Indiscernible) Corporation International Fuel Cells and now UTC Fuel Cells, and Hydrogen LLC, which is both a fairly new company and a really old company. The technology started back in the I don't remember when, in the 80's I guess. It sat dormant for quite awhile and has just been rejuvenated.

Now the most popular one right now is the United Technologies, and the main thing that I want to say here is when we talk about fuel cells, quite often we are talking about some futuristic thing, and you hear words like 2010, 2015, 2020, 2050. What I want to tell you is phosphoric acid has been commercial since 1992 and has been doing real work serving real projects out in the real world.

There is no question about the technology, it is robust. You will get out of this kind of a fuel cell, 40,000 or more hours. Some stacks are still original stacks, 60,000 some hours, and as I'll show you later, in 2007, UTC will be having an 80,000 hour warranty stacks that they are coming out with. So, this technology is ready to go. The only problem again is cost.

This is what they call their Pure Cell 200. It used to be called the PC 25, went through models A, B, and C during the time that I was working. I only dealt with one model A, but several model B and model C's.

Rob Taylor of (Indiscernible) was very involved in our phosphoric acid program assisting in site evaluations and the design reviews and things like that back in the early 90's.

This is what the Pure Cell 200 looks like if you take away the panels. Again, you can see going from left to right the fuel processor.

The power section, which is the stack and the power conditioner on the right hand side is just a little bit of physical feel for the three components I drew as a cartoon before into the real thing.

This was commercial licensed in 1992, it is a 200 KW AC power out, computer grade power. It will operate in the grid connect, parallel to the grid. It will operate without a grid and totally grid independent load following, or it will operate in both where it will be grid connected, but if you lose the grid, it will switch over to a second set of output terminals to serve a dedicated load up to 200 KWs.

It take 925 KBTU's per hour of feed. It has 925 KBTU per hour of feed output available. You can get all of that at 140 degrees fahrenheit or you can get half of it at 140 degrees fahrenheit and half of it at 250 degree fahrenheit of our options you can get there.

It is sold as being available for either natural gas or aerobic digester gas. Yan VanDokim, the CEO of UTC Power has told me if he can get a order for of ten or more, he will start manufacturing either hydrogen fueled or propane fueled models as well.

Electrical efficiency runs about 40 percent on a lower heating value. Overall efficiency if you take the electrical plus the thermal somewhere around 85 percent. I think in one of ours we ran above 90 percent actually.

Availability fleet wide is well over 96 percent, and that represents some early learning curves where people like myself intentionally find ways to break those fuel cells and make UTC fix them.

Ultra low air emissions, they have been exempt for air emission permitting in the South Coast Air Quality Management District. Their Amendment 209, which has been in effect for years, and meets and exceeds all the Carbo 7 air emission standards.

Stack life warranty right now of 40,000 hours, as I said, they now have some that operated around 61,000 hours, and they are still operating on the original stack. I think one of ours from our fleet with the Army was the first one to ever hit 40,000 hours, but you can pretty well be sure you are going to get one.

The cost is expensive. If you just by

one and you don't have any coupons or anything, it is $850,000, $4,200 KW. If you buy it in lots of about three, I think that drops down to about $775,000. They are willing to negotiate if you want to buy in lots of hundreds, which hasn't happened to date.

They have installed 275 units to date in nineteen countries and five continents and generated over 1.1 billion KWhs to date. They have over 7 million hours of fleet operation total at this point.

The Department of Defense Phosphoric Acid Program came about as a result of some congressional ads in fiscal year '93 and '94 that added $18 million and $18.5 million to the military procurement budgets to specify natural gas fuel cells in production in the United States to be installed on military installations.

The Defense Utility Energy Coordinating Council held a meeting in Washington D.C. with representatives from all other services including my organization to find out how this should be best managed.

The first question they asked was does anybody here have a clue what a fuel cell is, and

I was the only person who had heard of them before. So, they elected me to run the program for the Department of Defense, which I have been very glad of ever since. It has been a real fun ride up till I got a new manager, which caused me to leave, and now it is being a fun ride again.

We negotiated a turn key package with United Technologies Corporation. We weren't going to do that to begin with. The first thing we did is we put out a RFP. We invited all of the people who had commercial and natural gas fueled fuel cells in the United States to enter a competitive bid.

Then we took all those applications and did a very careful review which didn't a lot of time because we only got one of them, and so we consequently ordered a contract with United Technologies Corporation. We did that as a turn key package.

We ended up getting one Model A, and that is what we kind of call our illegitimate child. We didn't actually buy that, we paid for it. We bought that from Southern California Gas who had ten of them. They had a spare one in Vandenberg wanted one, and so that is -- we don't really count that one.

We did buy eleven Model B's in the fiscal year '93 appropriation and then in fiscal year '94, we bought three more Model B's and fifteen of the Model C's, which is what is now marked into the Pure Cell 200 fuel cell available today.

That included all engineering design, the installation. Training for our site personnel, diagnostic remote monitoring computer, and then we hooked them on sixty months of maintenance, scheduled and unscheduled.

About that time, they said, okay, where in the South Windsor, Connecticut area would you like to install these thirty fuel cells. Well, I showed them, and they weren't real happy. As you can imagine, we tried to break them so they had to fix them for five years.

We went through some huge learning curves, but it has really accelerated development of the UTC phosphoric acid fuel cell to the point that it is today.

You can see we had several California installations here, the Naval Hospital down in Camp Pendleton, the Naval Hospital out in Twenty-

Nine Palms, a Marine Corp. base, the Port Wanemi, the swimming pool up at Port Wanemi, Edwards Air Force Base, Vandenberg AFB, all the California applications for these.

We have also done numerous other fuel cell installations in California with our PEM Program and through our climate change rebate program. Unless I am mistaken, it was just the phosphoric acid ones today.

You see we've put them up in Anchorage, Alaska, places where it is quite cold. Out in the Mojave Desert, very hot and arid, down in the Southwest where it is very hot and humid, all over the country. You see there is a couple in Arkansas as well, that will tell you who was President at the time.

All of our sites were grid connected, so we distinguished the applications by what we use the thermal energy we recover for. On eleven of the sites, we used them as central heat plants to preheat make up water or reheat condensate.

We had seven hospital utility plants, again, some make up water, also hot water for the hospitals themselves. We had three sites that include pools or gymnasiums. We had an outdoor pool, an indoor pool, and a gymnasium where we actually coupled the heat to absorption shelters and provided air conditioning.

In addition, we had barracks, dining facilities, laundry, National Guard Armory, launch control building, an office, and a evaporator industrial process.

Why would anybody care about these kinds of military applications? Because if you take away the guns and bombs and tanks and things, well as a good friend of mind from the Air Force said, if you take away the weapons, the Air Force is just an expensive flying club.

That is kind of the way the Army bases are essentially, they are just a city. We've got restaurants, we've got hotels, cafeterias, laundry facilities, office buildings, industrial buildings, essentially everything you find in any kind of a city. So, we felt that the ability or the results we would get from these military bases would be equally applicable to the civilian world as well plus getting on a base where we owned all of our own electric clients we didn't have to deal with any kind of interface requirements and other things with the utilities. Locally, this saved us a lot of time.

I am just going to run through these real quickly and show you the different sites that we have. Each one I'll go from top left right and then bottom left right. The 90th 34 Air Lift Wing up in Minneapolis. This is picture at a dedication ceremony about mid April, which is what Minneapolis looks like at that time. When that fuel cell was installed, the high temperature for the entire two week period that the installation was going on was -10 degrees. I didn't go up and watch that one.

Herland Air Force Base, Albuquerque, New Mexico, that is another mile high city. We found the effects of altitude there, the fuel cells had to be derated to 180 KWs that high.

Nellis Air Force Base out in the desert there in Las Vegas, the Vandenberg Air Force Base up in Lompoc, California. That one didn't really operate very long. They started operating, and that is where they shoot off missiles. Vandenberg is kind of an unique area where they can shoot off both south and west without hitting any land.

One of the problems that they have there is that occasionally the missiles don't head south or west, they head for Santa Barbara or someplace like that, and that always irritates the constituents and Congressmen don't like that, so they have to have the facility to blow these things up if they decide to get off track. They do that quite often actually have to blow these ups. These are test missiles.

They use the utility grid to allow them to have the power to blow those things up. Of course, Congressmen don't want to have to explain to Santa Barbara that the grid was down so they had to blow up their town, so you have to run back up power, and they use diesel generators.

The Mojave Air Quality Management District has very strict limits on the amount of diesel generation you can put out in a year. So, a commander there basically came down to don't fire the missiles because you have run out of the amount of the hours you can put on your diesel generator or fired up the missiles and piss off the Air Quality Management District, which is what we chose to do.

We got half a million dollar fine, and through these negotiations they worked out with the Air Quality Management District and instead of paying the half million dollars, they would investigate fuel cell technology as a means to replace the diesel engines.

So, they put this fuel cell in, and I was getting some information back that the thing was going down quite often. I asked them to send me information. Well, they sent me data that for some strange reason it was going down about every third Saturday between five and six in the afternoon. I thought, gee, I wonder how UTC programmed that in.

As it turned out, when you are ready to fire a missile, they turn all these radar monitoring systems on, and that was interfering with the electric system of the fuel cell, and the fuel cell would go down. Before long, Mission Control up there figured out that people could monitor when they were going to fire a missile by watching the fuel cell. So, they ordered the thing to be shut off.

Despite some work to redo the electrical systems so that wasn't a problem, Mission Control never did really accept that, and they kind of let it sit and eventually it got moved off to another application.

Naval Hospital 29 Palms, California. This was about 7:00 in the morning in June. It was a dedication ceremony. You don't want to be out there past about 7:00 in the morning. The Naval Hospital up at Camp Pendleton there in Oceanside. Naval Education Training Center, Newport, Rhode Island. U.S. Naval Academy at Annapolis, Maryland. The Army Solider Systems Command, (Indiscernible), Massachusetts. Fort Ustiss down in Newport News, Virginia. Picatinny Arsenal in Dover, New Jersey. The Military Academy at West Point, here is the Air Lift Wing at Pittsburgh, Pennsylvania out at the airport.

Naval Air Station, Fallon, Nevada. You never know what is going to happen when you get a fuel cell. Before they put the fuel cell in, the top guns were all down here at Miramar. As soon as they got a fuel cell in, they moved top gun to Fallon, Nevada. You never know what will happen with a fuel cell.

Fort Richardson, Anchorage, Alaska, there is actually two there. We put one in and the State of Alaska put one in. It is one of the bigger tests we did of fuel cells. We put on semi (indiscernible) and tipped the semi over.

Fortunately, it was the State of Alaska (indiscernible). We found out how well engineered these were. It took about $35,000 worth of cosmetic damage and the thing was operating again.

Here we learned about ice fog, and you can see the stacks on these are much larger than stacks on most of the other ones to avoid some complications there.

Naval Air Hospital down in Jacksonville, Florida. Edwards Air Force Base again out here in the desert. Barksdale Air Force Base, (Indiscernible), Louisiana, just outside Shreveport. Fort Huachuca down in Sierra Vista, 4,200 foot we were able to fine tune these fuel cells to keep the 200 KWs despite the altitude.

National Defense Center for Environmental Excellence in Johnstown, Pennsylvania. The CBC Port Wanemi. Up here Port Wanemi was our outdoor pool application. Laughlin Air Force Base, Del Rio, Texas over on the Mexican border.

Naval Oceanographic Space Center in Mississippi. They liked theirs so much, they painted it. You can see on the front of it the kind of the fuel processor stack and inverter design I showed earlier. They painted that after some clowns. There is a little space shuttle up there. There is a sea gull in there, pretty good.

Westover Air Reserve Base in Chicape, Massachusetts. A prison down in Fort Bliss in El Paso. Subbase in New London, Connecticut. Little Rock Air Force Base and Pine Bluff Arsenals, both in Arkansas.

The Watervliet Arsenal up in Albany, New York and Davis Martin Air Force Base in Tucson. This is the one that was coupled with the absorber chillers.

You can see we put out thirty fuel cells there as our program, all of them on five year demonstration programs. We funded several other phosphoric acid programs through our Climate Change Fuel Cell Program. This is one that my friend Sam Logan, owner of Logan Energy up here in Fresno, this was a 600 KW program, three of the Pure Cell 200's coupled with a hundred ton absorption air conditioning unit. So, a little bit larger system, again, using the heat to our air conditioning. So, I just thought I would throw that one in, it is just kind of a neat picture.

Future developments. In 2007, they will be coming out with an 80,000 hour warranty stack life. In 2009, they will add another product, which is the Pure Cell 400. It will be a 400 KW fuel cell employing 2 of the 200 KW stacks.

Both the new stacks that are coming out in 2007 and the ones which will be the same ones used in the Pure Cell 400, will also be compatible with the current Pure Cell 200 or PC 25 C, so that they won't face the absoluteness that they did in going from the Model D to the Model C where they stopped making stacks for the Model D.

They also anticipate a price increase from the current 4,200 a KW down to somewhere between 2,000 and 2,500 a KW according to Yan VanDokim by the 2009 entry. That will be going in over this time frame. He is not real clear about what that will look like, but convinced that he can do.

The other companies, Hydrogen LLC, these are air cooled phosphoric acid company. The technology originated with Westinghouse back in the late 80's, early 90's. Westinghouse dropped the technology in the early 90's and concentrated on solid oxide.

The reason they did that really had nothing to do with the technology itself. It had to do with the fact that the Department of Energy had spent I don't know, several hundred million dollars supporting phosphoric acid fuel cells.

When United Technology did their lobbying efforts in the early 90's to get the money into the 93/94 programs for us to buy the fuel cells, one of the complaints came back as this is going to have to be a commercial entity. You are going to have some kind of commercial warranty.

So, UTC claimed this is now a commercial product. When they did that, the DOE says we don't support commercial products, we support product development, so they cut off all funding to the phosphoric acid. Westinghouse didn't have a commercial at the time, and they still needed the money.

Anyway, that sat around for awhile, and it has just been recently picked up again by a group, including Leo Blume, who I think a lot of you know from the Scandinavian countries. He is very well known. 55 minutes, okay.

The technology is 400 KW air cooled. As

I said, it was developed by Westinghouse with the Department of Energy some time ago. It was designed for industrial utility and multi-mega watt premium power applications. All the goals that met all of the R & D program milestones. They had millions of hours of assessment testing, but just didn't get far enough to actually get a product at the time.

What their standard product is, is a two MW power island. They use five 400 net output modules to come up with two MWs, and they are looking to put out power plants in the six to thirty MW range using three to fifteen of their power standard 400 KW modules.

They actually will sell two MW islands by themselves as well, but the real target range is six to thirty MWs.

Kind of a picture of the thing and just some of the features, 43 percent of the lower value of available hydrogen for the efficiency. Co-generation, 70 PSI steam at 360 degrees fahrenheit.

This is a hydrogen fueled fuel cell so it will produce up to 160 gallons an hour in a two MW system, which has been gathering considerable interest in the Middle East where water is a bigger commodity. In fact, they say the next war in the Middle East will fought over water not over oil because you can produce pure water with this and reduce your desalination needs.

It is air cooled. The one thing that it has -- the thing that depletes the phosphoric acid stack and limits its life is the depletion of the phosphoric acid. UTC has worked very hard at getting reservoirs to haul additional acid.

Hydrogen has developed a patented on the fly during operation additional phosphoric acid addition. Here is kind of a sketch of what the two MW power island would look like, single balance of plant. Again, from a manufacturing to the stacks, them taking four stacks of 100 KWs each net output, they come up with a 400 KW module, put those into a two MW power island, and then combine those two MW power islands into larger power plants.

(Indiscernible) reduction is the issue which depends on the simplicity of the stack, balance of plant, the fuel processor, and the size of the system. Hydrogen's philosophy is first they have what they feel is a robust technology.

Secondly, the unbundled the fuel processing, and the hydrogen infrastructure or mature hydrogen plant technology, and they are looking at large systems.

Basically, this is a hydrogen fueled fuel cell, AC out. They are looking at a couple of target markets, one is the waste hydrogen stream for like chloralkalide plants, one of the things like that produce a large stream of hydrogen. I know they have had some discussion of their products here, but I am locating one on their Southern California hydrogen pipeline.

For large system, once you hit about 10 MWs, they can go to someone like Air Products and say, bring us a reformer, we will run on reformate because the reforming technology is quite mature and efficient at about that 10 MW and above size.

What next? It is mature technology, most of the funding now is done in-house R & D to come up with technological advancements. Where is the real cost reduction needed? It has got to come through economies of scale.

The target price for stationary is less than $1,500 a KW, so incentive programs are outright purchased programs are things that would most benefit phosphoric acid technology.

California in particular because of the trap with population growth and its reliance on high priced natural gas for electricity generation, and its non-attainment could be a very ideal market for that.

One quick idea that we've been working on, or the Army along with Sam Logan and the Fuel Cell Test Evaluation Center in Johnsontown, which I established as part of my work with the Army, is what we call a hypo-gen, which basically takes a 200 KW UTC fuel cell and allows it to try to generate electricity, heat, and pull some hydrogen off after the stack in a storage tank or something like that.

I've been to Iceland a few times, and I see their hydrogen fueling plant, well as you saw on the slide earlier, there are three busses there, so the thing sits unused most of the time until one of the three busses come by. With this concept, you can always get as much electricity, up to 200 KWs as you want. When you need extra hydrogen, you just back down the electricity a bit, pull some of the hydrogen off, and then when it is not needed, you go back up and generate hydrogen.

So, this is a concept, a skid has been developed out at the Fuel Cell Test and Evaluation Center. We will be going out on a demonstration at Fort Stewart some time next year.

Again, this just kind of follows that. This is my company. That is our logo and our mission, bridging the gap from dream to reality, and we believe that the Hydrogen Highway is the way to get there from what is on the left, which is wait and grow's original concept of the first fuel cell anybody ever did, to the applications we are looking at on the right that we believe that fuel cells will fit.

Thank you.

MR. REMICK: According to the automatic clock, you have a minute and a half of questioning, so are there any questions?

MR. DEJONGUE: It is not always clear whether I am talking about this fuel cell (inaudible)?

MR. BINDER: My understanding right now is the 4,200 KW is the break even point on manufacturing costs without including any of the engineering costs. They are not making any money, they are not losing, as opposed to fuel cell energy low carbonate where they are losing money on every sale, they are subsidizing it. These are unsubsidized at this point.

However, Yan VanDokim told me what you have to realize with UTC's fuel cells is they went through a period of two management groups, the first one being just awful that were really out to destroy phosphoric acid fuel cells. In fact, ended production of phosphoric acid as many of you have heard, decided to make very large PEM fuel cells, which they were never able to get off the ground to speak of.

When Yan VanDokim came in as CEO, current CEO, he got rid of the large scale PEM, kept the automotive and the back up power side and went back to phosphoric acid. He just told me that there is a lot of technology that has been sitting on the shelf that was developed over these years with the very negative management that was never implemented. He says that they don't even need new technology. Cut the price and improve the performance has already been developed, it just needs to be implemented.

MR. REMICK: Thank you. I've already

introduced myself, so I don't think I want to spend time doing that again. I am Bob Remick, I am the Director of the Colorado Fuel Cell Center, so I got a commercial message first. I have been asked Art to say a few things about the Colorado Fuel Cell Center.

We are located in the General Research Lab on the Colorado School of Mines Campus. The Fuel Cell Center was started with a $2 million contract from the Governor's Office of Energy Management and Conservation.

I've been asked to read a message, and the message is from the Governor's Office is that no tax dollars were harmed in the creation of the Colorado Fuel Cell Center. The money comes from the Department of Energy by way of a stipper mine settlement, so it is actually a penalty being paid by people that are using federal lands to generate oil and gas.

It is made available every year for the State Energy Programs to use. They wrote a proposal, got the money, and we set the Fuel Cell Center up with that. So, no tax dollars, either U.S. tax dollars or State of Colorado tax dollars were used to set up the center.

The other issue is that the program, the Governor decided he wanted for every two dollars he put up, he wanted one dollar put up by the stakeholders in Colorado. So, there is $1 million being put up by the Colorado School of Mines, by the Gas Technology Institute, and by Diverse Power Systems, which is one of the solid oxide developers in Colorado.

Colorado is blessed by having four fuel cell developers. It is cursed by being -- I shouldn't say cursed I supposed, by being a red state, which is very conservative, and doesn't like to use tax dollars for anything. So, whereas Ohio has $100 million over five years from their Third Frontier Program that they are putting into fuel cell development to help their local developers commercialize their technology, Colorado has the Colorado Fuel Cell Center.

Our three fold mission is to provide state leadership in fuel cell technology development, to provide opportunities for public education on the benefits of fuel cells, and to assist the formation of strategic alliances between fuel cell developers and local businesses and universities.

We are concentrating on that third part there, to help local fuel cell developers commercialize their products, get them out into the market as soon as possible.

I moved to Colorado in October to take over as being Executive Director of the Fuel Cell Center. The first thing I was asked to do was be involved in a course on fuel cells for the engineers at the School of Mines. It was being taught by the faculty there, and they are a very good faculty members there that have considerable amount of research funding for fuel cells.

What I noticed when I went through the course syllabus that we mentioned -- half course was developed the PEM fuel cells and half the course was develop the solid oxide fuel cells. Number one, shouldn't the whole course didn't mention phosphoric acid or molten carbonate.

Apparently molten carbonate had fallen off the screen, the radar scope. I went down to the bookstore, and there were five different books on fuel cells that had been published in the last four years, and I started paging through them and discovered that only one of them mentioned the technology of molten carbonate. The other four didn't mention it except for a paragraph or two.

I noticed earlier we had an investment person mention, Dr. Wu, a list of fuel cell companies. The one that was missing was Fuel Cell Energy was not on her list, yet if you wanted to order a one MW fuel cell today, the only place you can do that is Fuel Cell Energy in Danbury, Connecticut, and the fuel cell they deliver is a molten carbonate fuel cell.

Manufactured in Danbury, Connecticut. The price listed on their website is $4,600 a KW for a 250 KW installation. It is a DFC 300, but it is 250 KWs running on natural gas. I am aware of the fact that the facility in Westerfield, Ohio actually cost $1.6 million, so that is more like $5,200 a KW.

I've been told from their website that they can get down to $3,000 a KW if you buy one of those one MW size plants, which is called the DFC 1500.

Now I will talk a little bit on the basic slides, not quite as fancy as some of the other slides, but we will get through the technology here. The molten carbonate fuel cell operates from 600 to 650 degrees centigrade, that is about 1,200 fahrenheit. That is red hot, you can actually see the fuel cell glow.

It uses lithium and potassium carbonates, which you may not be familiar with, but from the old days if you are over the age of 50, you may remember you could do into the supermarket and buy washing soda, which is a very caustic solution for removing grease from the walls. This is sodium carbonate. You can also buy sodium hydrogen carbonate, which is also known as bicarbonate of soda. So, this is all in that same family.

Mix these two together and heat it up about 485 degrees centigrade, and it melts. That is the electrolytes. Electrodes are nickel-based. It doesn't cost as much as platinum. These separators and hardware are stainless steel, but nickel and stainless steel, why they don't cost as much as platinum is not cheap either.

These are low powered density fuel cells, about 100 watts per square foot, about one-third or one-fourth the kind of energy density you need in the fuel cells for transportation. So, no one is going to use these fuel cells for transportation, they are stationary.

They are also not compatible with pure hydrogen fuel. Molten carbonate fuel cells must have carbon dioxide both in the fuel and the oxidant. It is needed in the oxidant to form the carbonate iron which is the electrolyte iron to carry across from the cathode to the anode.

Oxygen reacts with carbon dioxide to make the carbonate. In a one to two ratio, so you need twice as much carbon dioxide as you do oxygen from the air. You also need a little bit of carbon dioxide in the fuel environment to prevent the carbonate from decomposing. Steam will decompose the carbonates and the hydroxides. The hydroxides have ten times the vapor pressure than carbonates, and so you will slowly distill out your electrolyte if you don't keep a fair vapor pressure of carbon dioxide over the fuel.

So, you can't run a molten carbonate fuel cell on pure hydrogen. They require hydro- carbon fuels. The DFC 300 and the DFC 1500 require methane in the fuel because fuel cells produce heat.

A fuel cell running in its optimum fuel cell system, the whole system running at its optimum point of efficiency produces about one unit of heat for every two units of electricity. The same fuel cell system running at its maximum output produces about one unit of heat for every unit of electricity. You've got to cool the fuel cells, and this pertains to phosphoric acid, molten carbonate, PEM fuel cells, and solid oxide fuel cells, all have to have some mechanism for removing heat.

Because molten carbonate is running at 650 C, with a nickel anode, it will catalyze the reforming reaction. Methane plus steam produces hydrogen and carbon dioxide, but it also requires heat. So, that reaction is performed inside the fuel cell, not in the fuel process portion, but inside the fuel cell to remove some of the heat and boost efficiency.

You will also notice it produces carbon dioxide along with it, so the carbon dioxide you need in the air side of the fuel cell is simply shuttled over from the fuel side. Then the hydrogen is actually reacted on the nickel anode to make more carbon dioxide in the water.

The high temperature technology provides higher efficiency fuel cells. These are the DFC's 300's. They use 1920 standard cubic feet of natural gas per hour. They produce 250 KWs. That is about 250 KWhs. That turns out to be 47 percent efficient for production of electricity, but you can also recover about 300 BTUs per hour. Now you were recovering what 960,000 BTUs per hour. This will recover 300,000 BTUs per hour but as steam at 640 Fahrenheit.

Now recently fuel cell energy has announced that they just completed demoting their first combination of a molten carbonate fuel cell and a turbine. The turbine is run by using the heat generated from the fuel cell. I am not sure if this is a steam turbine or not, but the extra 16 percent of the heat is used to heat a working fluid, which is then used to drive the turbine to generate more electricity.

The electrical efficiency of that fuel cell is 56 percent. It was tested in Danbury, it is now going to be shipped to a hospital in Montana, so this is a free commercial or a commercial prototype.

You can't hit 56 percent in this size with anything but this fuel cell. The next thing that comes close is a 500 MW combined cycle natural gas fired power plant you can buy from

ABB. That will hit 55 percent fuel to electric conversion.

You are doing it here in a fuel cell that is 1/1000th as big as that combined cycle power plant, 56 percent. You can use that heat to offset the amount of natural gas you have, here is a co-generation. You can offset by using that heat. I can save myself 300 standard cubic feet per hour of natural gas, which brings us down to what would that be 1,620 standard cubic feet of natural gas.

We've had some bad press lately. The fuel cell in Westerfield, Ohio was shut down. I've seen all sorts of fuel cell fizzle was the name of one of the articles I've seen. Fuel cells all steam and no smoke or something like that.

I understand that fuel cell energy was inundated by calls from their investors saying what is happening, is this the end of fuel cells. Reading the articles on the what happened here, it says officials say the fuel cell was the victim of rising natural gas costs and a costly maintenance contract.

Natural gas prices quoted as high as $12 per million standard cubic feet, which I think is a mistake, a million standard cubic feet of natural gas is $10,000. I think that is really $12 a million BTUs. This was an article in the press.

Now the local electric rates were 5.5 cents per KWh. Has anybody seen 5.5 cents a KWh in California? All right, somebody back there has, very good. This is from the Columbus CEO Magazine. Let's look at what happened. This is realities of high fuel costs.

When this program was developed for Westerfield, Ohio, natural gas was selling for less than $4.00 a million BTU. That means the cost of the electricity degenerated by that fuel cell. The cost of the natural gas alone would have been 3 cents a KWh. You need to add to that the maintenance contract, you need to add to that the principle and interest on the money you bought to buy the fuel cell.

If it is now $12 a million BTUs, it is 9.2 cents a KWh just for the natural gas before you add in the other stuff. You are getting close to 20 cents a KWh in that installation.

Called up fuel cell energy and is this it in your program, and the answer is heck no, although they didn't say heck. We have so many orders for this fuel cell that if you order on the day we can't deliver till the end of 2007. What is going on? Because this generates a question, what if the fuel is free, what if the fuel doesn't cost you anything.

This is 1 MW molten carbonate power plant in Renton, Washington that is running on methane coming from a waste water treatment plant and anaerobic digestion.

This is making money because the fuel essentially is free. This opens up a whole new avenue for fuel cell not just research but fuel cell development. There are currently in California six molten carbonate fuel cells running for fuel cell energy, and I believe they've either got it already or they have just announced they are going to purchase one for California State University in Northridge.

These are up and running, the technology you can buy, the price isn't down to $1,500 a KW, but they are there.

Waste is power. I can remember California had less is more a couple of years ago, but waste is power is what we are trying to promote in Colorado. Molten carbonates have been demonstrated on methane from landfill gasses which are essentially free. All you need to do is clean up the solver.

The fact that the landfill gas comes out with methane deluded with carbon dioxide doesn't bother the molten carbonate fuel cell a bit, it loves carbon dioxide.

It has also been demonstrated on methane from sewage treatment plants and that is where those new all the extra orders for molten carbonate fuel cells are going now, for the methane from sewage treatment plants.

There are other alternatives that we are looking at in Colorado, methane from digestion of agriculture and food processing wastes.

California is one of the largest dairy producers. You can produce more milk than any other state. Milk implies cows, cows imply cow manure. What do you do with the cow manure? Is it being thrown into a large pond, is it being spread on the fields where the anaerobic digestion turns it into methane and carbon dioxide will simply go up in the atmosphere, methane being 20 times more efficient as a greenhouse gas than carbon dioxide.

Are you running it through digesters to make methane and taking the methane and using it to run fuel cells?

Streams from the production of bio fuels. This is something we have identified very recently. Biodiesel is very big I believe in California and Colorado. The production of biodiesel from things like soy beans. For every 100 gallons of biodiesel, you get 20 gallons of byproduct glycerin. The glycerin comes in three different grades.

High grade, this glycerin is being sold on the market as a commodity. In fact, the biodiesel people are so effective at selling glycerin that Dupont is shutting their glycerin plant because they are being put out of business by the biodiesel people.

The intermediate grade glycerin byproduct has a lot of fatty acids in it. It is going to right now, they are looking at other things they can turn it into. It may be a precursor for other commodity chemicals they might make.

The very bottom grade, the very worst

material saturated with lots of fatty acids in being landfilled. That has the material consistency and about the same carbon, hydrogen, and oxygen content as alcohol does. We feel confident we can turn that fuel process and turn it into a very good fuel for a fuel cell, molten carbonators and solid oxide.

This holds open the possibility of all those biodiesel plants can use their waste streams that they are not paying to dispose over the landfill to generate their own electricity.

Suddenly fuel cells were this distributed generation technology that was going to go where the customer was, or we could use to generate its own electricity and co produce his own heat. Now there is a second scenario and that the fuel cell was going to go where the waste stream is.

You say, okay, fine, we will build a huge 500 MW plant. There aren't places producing enough waste streams to make 500 MW power plants, but they are producing enough waste streams to make a 1 MW power plant or a 2 MW power plant. So, here is the new paradigm so to speak for things like molten carbonates and phosphoric acids, and in the future solid oxides.

I grew up in Pennsylvania, and as a child, I heard this thing referred -- this reference saying that they used many times, and I never understood until very recently what it meant. They said that the butcher used every part of the pig except the squeal.

We are quickly coming to the point where we are going to have to look at every waste stream in this country and see can I turn that into energy. Chances are that the fuel cell may be the way you can turn that into electrical energy.

I think that is the last slide. Oh, R & D challenges. We have identified viable waste streams, somebody needs to do a study, EERE would be a nice place to start. What kind of waste streams are available, where are they, and can we turn them into fuel cell fuel.

We need to develop processing methods for maximizing methane production from agriculture and food processing waste. We need to improve performance and endurance of the fuel cells. Molten carbonate has not yet hit $80,000 for stack, and we need to reduce manufacturing costs.

Thank you. I think we are taking a

break now, but I will entertain questions.

MR. RASTLER: What is going on in Japan and Europe? I know Europe particularly (inaudible)?

MR. REMICK: As far as I know, (inaudible).

MR. AMARNATH: Are there any other players in the (inaudible)?

MR. REMICK: Not that I know of. Are there any what?

MR. AMARNATH: (Inaudible), why are the other companies that are there --

MR. REMICK: One of the companies, I actually participated in helping (inaudible).

MR. BINDER: There is Gen Cell out of Connecticut (inaudible) --

MR. REMICK: I'm not sure what their status is, do you know?

UNIDENTIFIED SPEAKER: They have a (inaudible) with the University of Connecticut (inaudible) in Italy. Those are both (inaudible) according to (inaudible), they have come up with some very unique means of doing assembly line production including doing or putting the green cells in and (inaudible) melt down (inaudible).

Very innovative ideas (inaudible).

MR. REMICK: Yeah. That is what it takes, mass production. Yes, in the back.

UNIDENTIFIED SPEAKER: (Inaudible).

MR. REMICK: Was there a question? Fuel cell energy, I believe, at that time was called Energy Research Corporation, and Energy Research Corporation had two (inaudible).

We are scheduled for a break now, shall we be back in like 20 minutes.

(Whereupon, at 3:04 p.m., the workshop was adjourned, to reconvene at 3:24 p.m. this same day.)

MR. REMICK: I'd flip the lights up and down, but I don't know where the light switch is. Our next speaker is Gary Simon. He is President and CEO of Acumentrics Corporation. They manufacture rugged uninterruptible power supplies for all branches of the military and innovative new fuel cells that run on conventional and alternative fuels.

He is also President of Signa Energy Group, a clean technology investment and advisory firm. He serves on the Board of Capstone Turbine, Smart Power, and Rentricity, as well as the

Sacramento Area Regional Technology Alliance, and the McClellan Technology Incubator.

He has a broad-ranging 33 year career in both Fortune 500 companies and in small start-up businesses in consulting to major energy companies world wide and in government service.

Until retiring in October 2002, Gary was the Senior Vice President of Corporate Strategy and Business Development at Northeast Utilities where he had responsibility for corporate R & D as well as for business planning and strategic M & A transactions.

Previously, Gary was Senior Director and head of Global Power Practice for Cambridge Energy Associates where he provided advice on future directions of the industry and sources of strategic advantage. Gary was Vice President of Sales and Marketing for El Paso Natural Gas Company, a former GTI member as I recall.

Mr. Simon also served for four years as the head of the forecasting and planning for the California Energy Commission and five years as Senior Consultant to the Energy Committee of the California State Assembly.

MR. SIMON: I know I run some risk here

being last, so I've decided to be provocative.

Art had asked me to talk about solid oxide fuel cells beyond just what Acumentrics does. At the end of this presentation, there will be a quiz to anybody who knows how to spell Acumentrics.

It is hard to find on the web because everybody keeps misspelling it all the time, but it comes from acumen, skill, wisdom, and electrics or electronics. So, it is Acumentrics. So, maybe that will help people remember what it is. I didn't invent the name.

At any rate, also by being trying to be a little bit more expansive here and talk about other people's solid oxide fuel cells. Let me apologize to anybody in the audience who knows more about some of these companies than do I.

I know what I hear at conferences, I know what I get from talking to my colleagues in the industry. I know what I can get off the web. Beyond that, I don't have any special insight into what they are doing. We did want to talk about the solid oxide fuel cells more generally.

I want to talk about some challenges and opportunities. I think people know what solid oxide fuel cells are. They are high temperature device. Operating at high temperatures is both a blessing and a curse. It is a blessing because you don't need any expensive catalysts to reform light hydro carbon fuels. It is a curse because the materials that you use in them, therefore, have to survive the high temperature, and also if you want to start and stop the unit, they have to survive the thermal mechanical stress of expanding and contracting multiple times as you heat the unit up and cool it down. That is not an easy thing to do, and that is where some of the manufacturing challenges are.

Primary advantages. It has already been proven that the various integrated layers of the solid oxide fuel cell will last over 25,000 hours. We will go into a couple of companies and what they have done. They are tolerant of carbon monoxide. You can feed them pure carbon monoxide, and they will run on that as a fuel. That isn't an issue.

They will internally reform some light hydro carbons, but they have to be pretty light. I think there has been a lot of mythology about how much internally reforming a solid oxide fuel cell could do. I can tell you from somewhat interesting experience that they reform less internally than what the literature would have you believe, so they probably will come with some amount of external reformer as well as finishing off the reforming inside the stack themselves.

They are attractive because they are manufactured from inexpensive cell materials, nickel oxide, the standard stabilized zirconia which yeah they are expensive per pound, but you don't use that much, and cathode materials that are in the range of also some rare earth that use lathem, scandium, plus manganese. So, they do have the potential for being relatively inexpensive when manufactured in quantity.

Another blessing of the heat that they operate at is that you can use some high grade waste heat that comes out the back end. They operate between about 750 and 1,000 degrees depending on which system you are talking about, but the useful heat, by the time you go through recuperators, etc. is in this range of 400 to 600.

Where are the concerns? As you will see in a minute, if you are trying to build up a stack of plates, you have a big periphery to do a gas tight seal and also you are probably doing current collection of the periphery too. What materials do you have for that? They tend to be ceramics or glass, and so they are brittle. It also means you can't put them under a heck of a lot of compression to get a good seal. So, the plates that you are dealing with have to be pretty perfectly flat in order that you don't get leakage. So, that is a bit of a problem.

The other thing is, as you build up the coatings and as you fire the coatings, you sometimes have lack of uniformity. The big problem here in terms of the thermal expansion, the thermal mechanical stress is if you don't exactly match the co-efficients of thermal expansion of your anode electrolyte and cathode layers, they will spall off. Not a good thing.

A lot of work has gone into how you match co-efficient match the three layers so you can heat them up and cool them down.

Secondly, the thermal mechanical stress comes in if you are looking at a flat plat, if you don't heat it uniformally across the plate, you will get warping. You get enough warping, you will get a crack. So, this is different than a

PEM cell, which has a very flexible structure, low temperature, and therefore, doesn't encounter some of this.

The other thing that comes with a SOFC at least in the mythology is that you get low power density and low volumetric density. They tend to be bulky, but we will look at some systems which pretty much match what a PEM can do. There has been a lot of work in this area.

Because they will take carbon into the system, you can lose control of your fuel error ratio, and the system will basically make pencils for you. It makes a lot of graphite, the systems coke up, that is a problem.

That is reversible with hydrogen, but you would just rather not do it if you can avoid it. Now some of the coking comes about because you have a reformation zone and then a reaction zone, and somewhere in between something isn't right, and so you do a lot of work to try to keep uniformity, such that you don't get the coking anywhere through the system.

What do you do about this in terms of putting the system together and particularly, how does it relate to some of the manufacturing challenges that lead you to a lower cost unit?

Well, Acumentrics has taken an approach that inherently in a tube, you can solve some of these problems. In a tube, you have an advantage of geometry, that the only seals you are worried about -- the tubes that we make are extruded, so a cap goes at each end to close them off. You just have to seal around that periphery. Whereas on a plainer system, you have to make a seal around all four sides. Terms of the total length that you have to seal for the tube, it is easier.

The other thing that you have an advantage with in the tube is that if it is only clamped at one end, as it grows and shrinks through a thermal cycle, it doesn't matter. You are not trying to hold it steady at both ends. With a plate, you have some problems dealing with the size change in the plate as you heat it up and cool it down. So, the seals that you make there have to be able to slip a little bit as the systems starts up and cools down.

Finally in terms of residence time, ours operates at a relatively low pressure, only half a PSI for the fuel on the inside because we have a lot of cross sectional area there. We can get good reaction of the fuel on the inside in a more compact plate system. You have some issues on the flow fields in terms of how fast you can move air and fuel through, so they usually are pressurized. Now you have some parasitic losses from compressors trying to buck the Delta P you get across the system.

In terms of thermal cycles, this is where a lot of things happen positive for us. We have done over a hundred thermal cycles many times with our units, most of them inadvertent. Fuel gets cut off in a laboratory, power gets cut off because we are not in a particularly good part of the grid, so we have accumulated hundreds of thermal cycles, and we do think some degradation, but it is pretty minimal.

On the planer, they really like to limit their thermal cycles to a small number. That number is directly from a company we are going to talk about in a minute is VersaPower. Don't need the pressurization, do over here. This will do some internal reforming, probably this all has to be external reforming over here.

If you try to get a planer system through internal reform, you have an endothermic zone across the plate where the fuel is being reformed, and that is pretty cold. Then you go to the reaction zone, and that is pretty hot. That puts a lot of stress on the plate. That is kind of hard to get it to do internal reforming consistently. Our tubes have so much volume in there, they tend to be pretty immune to that problem.

We use a metallic seal at the end. We braze it on with copper. It doesn't matter whether it is perfectly round or not, the copper is forgiving and it seals in. This tends to be a brittle glass or ceramic material and get the flatness problem. Our interconnect, because of the temperature and the oxidizing atmosphere, we use pure silver. You can use something different in a planer. We actually don't use that much silver, so it is not too much of a disadvantage.

We have a support on a nickel tube. A lot of the planers, in order to get good mechanical stability, use a metal plate, a metal plate for their mechanical stability and a little bit more expense there.

Power density is getting up there. These are figures both on hydrogen 330 MW per square centimeter on ours, 420 MWs per square centimeter on Versapower's system, so that includes no effect for the internal fuel reforming. This is a hydrogen number on internal reforming. Numbers will be less.

Compare that to PEM where the numbers are in the order of 800 MWs per square centimeter. It is not that far off in terms of the compactness. With us, the reformation can be very small packages because we don't care about stripping out the carbon dioxide and carbon monoxide, just let that pass through.

In terms of the volumetric density of an entire package operating on a hydrogen carbon fuel, we actually compare very favorably to the PEMs.

Here is a typical stack structure. I know these are hard to read from the back of the room over there, but basically you have a flow field of fuel going one way, air going another way. You've got some anode and cathode pick ups in terms of current. The green part is nickel oxide base. You've got a couple of coats on top of that, and these are the seals. Stack that stuff up, clamp it all together.

The company that we think is really doing great work on plain or solid oxide is VersaPower. I've stolen this off of their website just in terms of looking physically at the way this is constructed. They have done a lot of good work in how you are bringing fuel and air in, putting it through channels. We have a lot of good work here on using your seal material to also make plenum, and then you see how this all stacks up.

That is the way a VersaPower stack looks. That particular stack probably is 600 watts, so they stack these up, gang them, get the sizes and the KW, the multi-KW range, and then a lot of balance of plant, etc. You need pressurized fuel and pressurized air coming in to get enough flow through the system to get your power density up.

Here is our system. These are the tubes that we use to kind of get an idea of the size there because there are some gages down here, but the tube is about fourteen inches long. It is 15 millimeters in diameter, that is the silver wrap, that is the cathode pick up, the manifold where fuel flows in is the anode. Fuel flows in, goes through these tubes, comes out an orifice, reverses field, and goes back down along the tube. If you could see it fairly well, it comes out an annulus around the injector tube. So, it is pretty compact design where you get both the fuel in and the exhaust out on one manifold.

They are parallel across, so even if you lose some tubes, the system continues to operate relatively simple current collection, although as you can see, it is a little bit bulkier than stacking up those nice plates, but we get the other advantages that come with it.

Now we have changed our current collection technology, and I am not going to talk to you about that, but we do it slightly differently now, and that actually that tube in the picture was producing 14 watts, the tube that we have now produces 60 watts. So, it is getting up there, and we have another tube that has already done 100 watts in lab bench. Each tube is getting to be a significant contributor.

The system looks like this. Those manifolds are stacked up. They are bolted together with a big head bolt that looks like something off a car, four stacks across. Used to have 21 manifolds high, the new system for five KWs is just these bottom two rows because of the extra output per tube, there are actually fewer tubes and fewer manifolds, so it is much more compact.

Heat exchanger up here is a recuperator. We have a different design for that now. I am not going to tell you what it is. There is a final heat exchanger up here is a water coil. If you want to make hot water, but basically, air comes in, goes through the recuperator, on the other side, comes down, and flows to the bottom, comes up, out, and exhaust that way. Fuel comes in through the manifold, and there is a burner down here to get it hot initially.

Now there is sort of a mid point on solid oxide fuel cell technology between flat plates and tubes. There is the flattened tube. There are three manufacturers that are using a flattened tube. Some issues on that, though. This is one from Kyocera. That little paddle, and it is about ten inches long, as their diagram shows, they have a support plate which is very porous, then they have basically the anode, which is that, the electrolyte layer, and the cathode all on the porous support plate.

How do they get it on there? Actually these three layers are all tape cast, which means they are putting them out with some support, they are centered and dried, and then you have to glue it onto the tube.

So, the gluing and the sealing, not the easiest thing in the world, so they have a lot of ceiling area here to make sure you maintain a gas tight seal with all the shrink and swell of thermal expansion.

They have a five KW system operating. So, there are some interesting possibilities of that. Uses an interconnector on the back and you just stack these things up. They sit vertically, and then with a little piece of nickel foam in between them, they just all connect at the bottom to make the electrical connection. Clever, but pretty expensive to make.

Here is where Siemens Westinghouse is now. They used to have big round tubes. Where is Dan Rastler? You remember the big round puppies with the skunk stripe down the middle for current collection. Somebody stepped on them, they now look like this. They are actually longer than is shown here. That is a ruler showing six inches. They are about 18 inches long, they are getting longer. They are trying to make 100 watts per tube now.

Current collection, that is a nickel stripe there on the anode side. There is a cathode pick up on the other side, and they just basically stack together. You are trying to get in this case fuel on the outside, air on the inside to circulate.

Rolls Royce has a flattened tube. They really have got themselves a sealing problem because it is not like Kyocera where each paddle has a peripheral seal, now they have done it in windows, so each window has a seal. They are very stealthy. I don't know exactly what they have done there, but I don't know what their current collection precisely is.

Something we will look at here in a minute, it looks like they have an interconnector down here. It looks like gas flows, probably air flows as well, but the gas flows on the inside, and there is some connection up here. They've got some significant sealing issues there, but they have indicated that they are ready to go to volume production. They are trying to open a $100 million production facility in Singapore. They've never shown in any presentation that they've actually done technical demonstrator, but I would assume that they have.

Now you are going to test the limits of my abilities here and see if this video will play. Naturally it doesn't. Let's come back to that. In terms of how they stack these things up, they've got their little plates. They clip them together somehow, and then they seem to have fuel down at the bottom, but it is a fairly good process, so let me just see here if I can figure out how to do this.

There we go. You probably can't hear. It says it is playing.

(Video playing.)

That is a drying oven there. That is really fuzzy. That is screen printing on the little windows. There was the little gas connector there, and then there is an innerconnector over here.

Put the number around the core, stack it up. They are going for the big size too, they are going for the 250 KW basic module. They require a compressor, which is that little thing out there. That is a four MW system. Haven't built one yet, though.

Let me see if I can turn this sucker off. Now we will come back here. All right, so, what does this mean? In terms of where people are, we've looked and talked about the road maps. Here is one way of looking at it going from single cell in the lab to a commercial product. Again, based on what's out there that I can find, I sort of indicated where I think people are.

The lavender is the planer guys, the greens are the flattened tubes or the tubular guys. A lot of stuff has made it to technical demo. Some things are probably a big behind that. Some companies may not go forward.

Sulzer Hexis is sort of on life support for a year. I think ZTEK is probably finished. Some of these will drop off, and people that I couldn't find information for, I didn't know where to put on here, so I left them off. Siemens Westinghouse has done big systems and through another company called Fuel Cell Technologies Limited in Canada has been doing small systems.

We are here. We have twelve 5 KW units

in the field. We are in product development and probably you would say that Rolls Royce and Ceramic Fuel Cells and a few others are probably here, but just trying to be apples to apples.

I haven't seen a whole lot that is up here in terms of actual commercial product development out there in public presentations. If I were to take a company like PlugPower, a PEM company, I'd say they are probably in here. They have done a lot of product development, probably not fully up to manufacturing scale which is where they want to be. A lot of companies partially along the path.

What does this mean for some opportunities that you have? I think solid oxide fuel cells because of low cost, their ability to start and stop, their ability to use conventional fuels, and their durability, have a pretty good chance of being commercially viable fuel cells, both for stationary and portable applications.

Put a plug in here. I attended a presentation by John Dewar of Cliner Perkins in San Francisco recently, and it was basically titled "The Hydrogen Economy is Dead" and his point was it is too complicated, it is too expensive, VC's are not going to put money into it. Biofuels is what we need to be thinking about. So, at least keep in mind on R & D the radical thought that maybe it is biofuels that you need to be compatible with for the fuel cells.

I think there is a lot of thought out there that SOFC's are way behind PEM's. I don't think they are that far behind PEM's. There has been a lot of advance in the last couple of years. In terms of opportunities for the Energy Commission, I think you could probably spend a lot of time trying to pick winning technologies and technology advancements. It is very time intensive.

Thinking about this, I said, well, what if you just set up incentive contracts. You don't get one unless you meet certain entry criteria. You don't get half of your money unless you can at least demonstrate "X". You don't get all of your money unless you can demonstrate "Y". There is a possibility of a bonus if you can do even better and demonstrate "Z". So what are X, Y, Z like?

This is just a guess, but I said if you are trying to direct yourself towards a commercial program, you are interested in efficiency. I think you should be interested in a system that starts and stops relatively easily and quickly where the degradation is going down, so it is another measure of durability, and that you can show operation for a number of hours of reasonably good availability. That is progress towards a commercial product.

Rather than putting a bunch of demonstrations up, where you are not sure whether they are going to advance towards that course or not, one thought would be to set up something where you actually don't get paid unless you achieve targets that you would determine would be useful advances of the technology towards a commercial product as you see it.

As I say, you could think about all the different ways of doing that and you might even want to take it farther. I've said on here efficiency on natural gas. You might want to do it on other fuels, renewable fuels, renewable fuels ultimately.

Think about funding a number of teams and let them sort through the technological possibilities of how to meet these goals rather than you trying to figure out whom to back in individual technology advances.

There was a broader question. What else could the Energy Commission do to advance the possibilities of fuel cells? We have talked this morning and heard the presentations from Stephanie, Marianne Wu on the possibility of integrating fuel cells into the grid, the fact that they do give potential grid support.

Right now there is a problem in that, wow, that support is given. It is not easy to take the benefits that fuel cells give to the grid and get a payment for that.

Many of you will remember integrated resource planning, least cost planning. It swept the country. Almost every PUC said before you install new generation, look at all the alternatives and install what is least cost in sort of a systems look. It has to meet environmental requirements, it had to meet system reliability requirements, financial requirements, etc. etc. etc.

That put a tremendous push behind advancing some new technologies into the system when you looked at in that comprehensive way.

Through the deregulation of the industry and a lot of changes, hardly anybody does least cost planning anymore, and I don't know that it is all that necessary. I think probably the entire market has caught onto it. What we do lack is looking at it the same way at the distribution level.

When you propose to expand poles and wires, when you propose to put a substation in with big capacitors, do you look at the other alternatives, and then the follow on to that is under what became of least cost planning integrated resource planning, you paid the avoided cost to the alternative generator for what it was worth to come in with their system versus what conventional would be.

What if you paid generators the alternative costs, the benefit that they are providing to the system for the grid support that they are providing.

Dan Rastler's organization did a study, hard to see from the back of the room I know, but they looked at a number of ways to improve a distribution system. These dotted lines are the conventional ways to provide power quality, do some load shifting, grid voltage stability, grid angular stability. We are talking there about the reactive power. So, there are some prices down here. These are in dollars per KW, that it costs to use these conventional alternatives. If you had a device which provided the same benefit, shouldn't you be willing to pay that party a price, say 90 percent of that in order to install it, in order to advance the technology and even get a little bit of savings. It would be the idea of least cost distribution planning.

What we have up here is mostly storage technologies, but you could get it as well as a part of the package in installing a fuel cell. The point is, if the fuel cell is worth to you on an energy basis deep in the system a couple of thousand bucks per KW, this would add another couple of thousand bucks per KW just for the grid stability benefits.

I think there is a gap right now that while these benefits are being provided by distributed generation, not just fuel cells, but a number of things, that benefit is not flowing back to the party that is putting the system on the ground.

I would make a plea for the resurrection of least cost planning and call it least cost distribution planning. So, another idea there and food for thought.

That is it, thank you very much.

MR. REMICK: Art, we are going to do a panel, right?

DR. SOINSKI: Right.

MR. REMICK: (Inaudible.) First off, I want to thank you for saying nice things about VersaPower since they are a Colorado company.

MR. SIMON: What is the CEO's name? It is Robert --

MR. REMICK: Robert Stokes.

MR. SIMON: Stokes, yeah. Doing a great job.

MR. DEJONGUE: There are some projections for additional generating power that is needed in the next 20 to perhaps 50 years, numbers on the order of terra watt. What kind of problems or perhaps opportunities does that present for fuel cells?

MR. REMICK: I was actually trying to get Grover Coors to come here and talk because he is the only gentleman I've seen out who is actually making presentations about what it might look like to produce a giga watt of fuel cells.

You need a tremendous investment in manufacturing facilities. It doesn't matter what fuel cell technology you pick, it is going to be -- fuel cell energy for example could easily sink four or five hundred million dollars into building their next manufacturing plant to make the kinds of markets -- to be able to meet the kind of markets they could have if they could get down to $2,000 a KW.

The market is very large, but the investment in the manufacturing facility also is very large. So, that may be the -- I hate to use the phrase, but the chicken and the egg for fuel cell development. Yes, you can reach markets, you can put 400 fuel cells, process the fuel cells out and demonstrate them, but it won't make a darn as far as the energy situation is in the United States. You've got to get huge manufacturing capability on line.

MR. SIMON: I guess what I would say is if you go back to our presentation from Mohr Davidow, if you look for markets that provide that price umbrella where you can make a compelling case right now, they tend to be small scale systems.

At least Acumentrics approach is to exploit those markets first, mature the technology, and then get bigger. For a long time, we wouldn't be trying to attack something at the 200, 400, 500 KW scale. There are very good alternatives there, engine technology is getting much better, emissions are coming down. It is tough to go out in the market when you are facing that kind of competition. When the competition you are facing is a Honda generator that doesn't run more than about an 100 hours before it ceases up, that is a much better one to go after.

I don't think in terms of fuel cells making a big dent at that huge scale central station power it is going to occur in my lifetime. I do think under 25 KWs, it has a real opportunity to go out deep in the system and provide a lot of the alternatives I talked about. So, I'm not worried about Grover Coors making a bunch of ceramic tubes for fuel cells. I don't think that is where the market is going to be in the next say 20 years.

MR. REMICK: The question then I guess arises if I can interrupt here is why are we investing large amounts of ratepayer's money in fuel cell development then if it is not going to make a significant impact on the energy situation in California?

MR. SIMON: I didn't say it wouldn't make a significant impact. I said it wouldn't be big central station power plants.

MR. REMICK: Okay, I agree, but are you going to build 10 million fuel cells, residential fuel cells would make a large impact. You still have to have the manufacturing facility to build 10 million fuel cells, and that I think is Grover Coors plan.

MR. SIMON: I just don't think that's the scale that you are going to start with. That is going to take quite a bit of time. Photovoltaics didn't start with worrying about how you are going to make 10 million square feet of photovoltaics, you started with making a few square feet, and now it has grown into something that is having a significant impact.

MR. REMICK: Probably really objectionable. The book, and Dreyfus I believe his name who wrote "The End of Oil", well, he starts with a discussion of photovoltaics, and he says if you took every roof of every single family dwelling in the United States of America and covered it with solar shingles, and then connect it off the grid, you could pre generate maybe 10 percent of our electric demand, which is about 3 percent of our energy growth.

Which means supposing you build trillions of dollars to do that, what are you going to do next year because our energy growth is growing about 3 percent a year. So, I would argue that even to do it with solar energy, you are going to have to have one very large manufacturing facility.

MR. SIMON: You add up solar and everything else, suddenly you are making a dent. If you would have asked your question on nuclear power in 1952, you know, that started with some relatively small power plants. We look today, and 9 percent of the installed capacity is nuclear, would you say wasted money, we should have gone for something that by now would have been 50 percent.

MR. REMICK: I would have asked why not go for the big stuff. If the market is going to take until 2020 to develop more fuel cells, they are making an impact in the energy technology, then why shouldn't we redirect what we are doing?

MR. SIMON: Customers make millions of small decisions, and they add up to big impacts, and I just think that is the end at which fuel cells will make a difference.

MR. REMICK: Okay. There are some questions in the back. Go ahead.

MR. SKAGGS: This question is for Mike. Mike, I just wanted to get your reaction to Gary's parting comment on one of his slides stating that SOFC has the best chance for commercialization.

MR. BINDER: I think for large stationary scale SOFC is going to overcome both phosphoric acid and molten carbonate someday, but I think there is a very large window before that is going to happen. I don't think it is going to happen in any of our lifetimes here, you know. If you even look at the type of things, the 2012, 2015 time frame to really initiate commercialization of the smaller units, you are talking quite a ways out before you are going to see large scale penetration of SOFC into the market.

Phosphoric acid is doing quite well

because it has been here since 1992 when the manager that decided he didn't like phosphoric acid dropped the phosphoric acid side, fuel cell energy saw an open door and they stepped right into it. I was very excited at that point because we had a sure winner with phosphoric acid. I thought it had a proven ten-year history. We knew you get 40,000 hours on it and fuel cell energy, you didn't have anything at that point. They were just starting.

Now fuel cell energy has a good 30,000 hours demonstrated on units that seem to be working quite well and larger units like the one in King County on the ADG. They have really taken advantage of that open door that UTC left open.

For quite awhile now I think there is going to be markets for everyone. There are certain temperature advantages, cost advantages and things, absolute technologies occur and certain technologies will fit into certain markets before others will.

I think the be all and end all at some point will probably be solid oxide for stationary applications.

MR. ADDISON: Trying to get a better

understanding of where the market speaks about how these technologies are going to enter into the marketplace. Could you comment on what those sweet spots are and how they are going to evolve over time and you already talked a little bit about what the penetration would be once they reached those sweet spots.

The second question that I would like you to address is the incentives that are out there, both at the federal and the state level, are those incentives really hitting their target, and how critical are they to allowing the technologies to mature and develop to the point that they can reach those sweet spots and make significant end roads into power production.

MR. BINDER: Let me answer your second question first. Sam Logan runs Logan Energy. He is a very good friend of mine, and he makes a living as now an international company, international offices doing fuel cell projects, including financing, purchase, design, installation, and maintenance. So, there are people actually making money out there in fuel cells.

I think he will be very quick to tell

you that without the incentives, the market would drop considerably. When you talk $1,000 or $2,000 a KW in federal incentives and state or federal tax credits and put them with something like a $2,500 KW credit in the State of California say or the ones in Connecticut or Ohio where some of these others have come up with. I think without them, you would not see the demonstrations that we are seeing right now.

The big sweet spots in the market right now are where you are competing with battery power I think, and that is the back up power systems. I think most of these stationary companies now have remote hydrogen powered back up systems. A study that Mike Driscoll with the Federal Aviation Agency and myself have done, we were able to demonstrate that if you need more than four hours back up capability, fuel cells are viable at today's economics versus batteries for back up systems.

That is certainly a sweet spot. Plug Power has been trying to get into the residential home market for years. They have been doing these gen systems on natural gas fuel, five KW residential, and they are really getting out of that now. I don't see with the high price of natural gas that those are going to be real competitive in the near future.

Their new gen systems too that will be coming out in 2007 where we get propane power DC output, five KW unit meant for the full time power for the remote telecommunications markets. You can put an invertor on those and they become you know power supply for residence that are out remote away from the grid, away from the natural gas lines, and something like that. They will generally have a propane tank.

The other big market is in the military. As I mentioned at the National Hydrogen Association Convention, the military generally quotes a very cheap price for their fuel because they are given the annual or the average price world wide that they pay for fuel when they buy it in bulk in the United State delivery dollars.

By the time you take a logistic fuel and you stick it on a C-141 and you fly it to someplace out in Iraq or Afghanistan, you take 500 gallons of that and you fly those by helicopter a few hundred miles into the front, you in fact can end up paying as much as $600 a gallon for that fuel delivered. At that price, even the slightest bit of efficiency improvement brings about a good dollar cost.

Plus the political arena we are playing in threatens that particular supply of fuel anyway as well. So, I think that is a very good market. In fact, recently the military has been ordered that they will start reporting cost of fuel on an actual as delivered basis, and I think there is going to be a much bigger opinions out there.

The problem that fuel cells face in the military market is the one fuel forward policy that says we have JP 8 there or JP 5 or whatever it might be in logistic fuel for our aircraft, therefore, everything is going to run on that. They won't allow hydrogen, but the hydrogen refueling is eventually going to have to be done with logistic fuel. So, there is a great deal of effort being done right now on logistic fuel reforming.

In fact, just a couple of weeks ago, there was a big logistic fuel reforming conference down in Florida. When you look at that kind of price of fuel, the military is certainly a big market. Their base camps or bare camps that they stick out right now have something like 27 different types of generators that come. The main ones being four 750 KW diesel generators that form a central grid in the city.

It takes something like for every 1,100, it is like AC 141 just to carry the generating equipment and then fuel supply gets to be absurd on top of that. So, the idea of going to a fuel cell that could be DC bussed together is what you have essentially one piece of equipment, one set of maintenance parts, one set of maintenance instructions is something that is being looked at very big too.

MR. SIMON: I think beyond the military market, and I would agree with everything that Mike said, there are some other remote applications, Mike, where they have a similar fuel problem.

We have some standing orders from people in wilderness areas in Alaska, and basically they are on propane fuel, but it is coming by float plane. So, these are houses that are occupied for only a couple of months in the summer. Again, if you can show that you have substantially better efficiency and by that I mean you can show at least 35 percent efficiency when their little propane powered internal combustion engine is about 14 percent efficient, that is pretty compelling.

For the military, silence is also compelling proposition. Then you move from those markets and on the issue of incentives, in Japan, they are offering $60,000 per KW incentive payment for solid oxide fuel cells to be installed over there. That is a pretty good market. That is a serious program. I just worry about things where it is like $2,500 a KW as to whether that actually advances the market that much.

MR. REMICK: I have to agree with Gary. We have done some studies. There are I believe something like 100,000 remote homes in the United States, homes that are not connected the grid, and if they are not connected to the electric grid, they are probably not connected the natural gas grid either.

They are heating their places on propane. In many cases they are using diesel generators or gas generators running on propane as well to generate their electricity. Or they've got $12,000 worth of solar cells on top of the house. Those become substantial markets for propane powered fuel cells.

I would argue with one respect, Mike, I understand from mesoscopic devices, that there are propane powered cook stoves in Iraq, so they have got some fuel cells over there being demonstrated on essentially the propane they use for cooking. That is that nitch market that could easily get in. For example, iconmetrics, get into that.

One thing that most small companies love to do is they start turning a profit on something to encourage their investors.

MR. SIMON: They don't move the propane that far forward though, so --

MR. REMICK: No, they don't.

MR. BINDER: Therefore, the small fuel cells like mesoscopic devices, the fuel canister is hydrogen or (indiscernible) and things I think are approved. I am talking about more the larger set that is going to go forward.

MR. ADDISON: Those examples I think were more technology opportunities and technology sweet spots and not market sweet spots for supplying electricity, in this case to California or into the nation. What I was trying to more focus on is how are fuel cells likely to impact the electrically supplied market for California. Where are the sweet spots where it is going to make a difference. A couple of percent here or there, I mean, we are talking about some numbers with residential fuel cells, you know, the Plug Power example of 5 KW.

Where are the fuel cells going to impact the electricity supply market in California or in the nation, not these remote examples that you were talking about?

UNIDENTIFIED SPEAKER: I think that is the thrust of what we are trying to accomplish here.

MR. SIMON: I would just quarrel that, you know, the remote market somehow are immaterial. They are the ones that will get the volume up on the technology. So, if you can have something like least cost distribution planning, which could add another couple of thousand dollars of KW and these early markets can get you down to the point where you can make money at $4,000 or $5,000 a KW, then with the incentives that are out there, the least cost distribution planning, then you can start understanding that you could be putting those throughout major parts of the grid.

In terms of how do you advance the market in volume, I don't think that any state or even the federal government is going to be willing itself to make the volume purchase to get the manufacturing to a level to say that you would be economic selling at $4,000 or $5,000 a KW.

I think the military, the remote, some other portable markets, they are the ones that are going to advance the technology to that stage. Then you are going to be at a level where you can make money advancing into larger parts of the California market.

The issue that I see with going with large installations is that the larger you get, your alternatives are going to be engines which are already 30 to 35 percent efficient and emissions are coming way down. Not such a compelling proposition. So, I think in the Clay Christianson mold, what we are looking at here is the classic attack from the bottom.

That what actually wins is a device which is relatively low in performance and relatively high in cost and it begins to fill nitch markets and the niches expand, and suddenly it is not Steve Jobs and Steve Waszniak pounding things out in their garage, you have revolutionized the industry.

I think it is the same problem, Mike, of saying, okay, you've got the Altair 880, I think that is what it was. Great, a hobbyist computer. How is that going to effect IBM and concluding it won't because it is just too damn small. How did that one come out?

MR. ADDISON: What I think I am hearing is the pathways to markets, but the markets are really going to be the smaller scale, the residential small commercial, not industrial, not obviously not the MW size range. The markets that you are designing for in the future through these pathways are still going to be in the 20 KW or 50 KW and smaller size ranges?

MR. SIMON: I think that would be our view as in a place to start, and then you are going to see how that matures. The thing that I was always impressed with was I got my first HP 21 calculator whenever that came out, and it cost me -- I forget what year that was, but it was in the 70's, and within ten years, my son's watch had more capability than a HP 21 calculator.

Now, I don't think there is that kind of Mohr's law going on in fuel cells, but I make no apologies for saying I think the entry into this market is through the small scale stuff because you are taking on alternatives which are worse than what you have.

If you start with the big stuff, you are taking on alternatives that are better than you are. Why start there.

MR. REMICK: I would argue that the MW, there is a place for the MW power plants. Again, the point I am trying to make is you are looking for alternative fuel streams. You may be right. If I am running on the natural gas system, I may have a tough time competing against reciprocating engines in the MW class.

If I am running on material coming from waste water treatment plants or other areas which we haven't yet identified, then the MW fuel cell might make a lot of sense, especially to industry, especially to the people who have to pay through the nose for electricity during the day time.

MR. SIMON: Unless you have the same internal combustion alternative for landfill gas and digester gas.

MR. REMICK: Exactly.

MR. BROUWER: Jack Brouwer from UCI. I appreciate the realism. We should not be overly optimistic with regard to fuel cell technology which is pretty typical.

I also appreciate the need for many companies to focus on markets that make sense today. I think that is good. You see that happening with remote power, back up power, places where customers can make money by purchasing a fuel cell today.

The same goes for waste water treatment often. You can sell it to customers, and they can appreciate a rate of return. I think, however, that the Energy Commission has to have both a short and long term view, and perhaps needs to develop a road map much like the road map that Dr. Garland talked about that DOE makes.

All these technologies can have a role. The technologies that can have a very significant long term impact, even at the central plant scales, DOE is investing in that. Should the Energy Commission have that on their road map. Big multi MW power plants.

As a matter of fact, even today, fuel

cell energy could install multi MW power plants in California, and it would start to make a difference.

I am a little bit discouraged to hear only a focus on the early markets. I would really like to see the long term road map be developed and have these other products spin out. I mean that is how Plug Power is now selling systems. Ballard is selling these systems in Japan. They weren't necessarily original. That is not necessarily the long term plan that DOE had with some funding for automotive applications, but some of this technology spun out and does that.

I'd like to see a road map that gets us to both supporting these early markets and supporting the long term, maybe multi MW markets. I don't know if that is a question or a set of comments.

MR. BINDER: I think that's the objective of this week and particularly tomorrow is to focus a five-year road map for the CEC PIER group, and I agree with you there. There are some sweet spots right now that can be economically viable today, but as I said in mine, hydro gen is starting with the 2 MW of basic and looking to go up from there.

Fuel cell energy, since they really don't have any interest in selling those VFC 300's, they really are looking for the MW and two MW systems, that is where it makes more sense. Siemens is looking at the larger as well --

UNIDENTIFIED SPEAKER: Rolls Royce is.

MR. BINDER: Rolls Royce is doing some excellent work in their development for large systems, and I think there is going to be room down there. Hydrogen right now is at 3,000 a KW for a two MW plant and will go down to about $1,500 a KW at a 10 MW plant. You are pretty viable right now, but, of course, that is hydrogen fuel with that group.

What would really help is if somebody had really deep pockets and could go out and go to a FCE or UTC and buy up slots for several years of hundreds of these fuel cells so that they could forward price, get the best price from their suppliers.

They would then essentially have a monopoly over the fuel cell market, could resell those prices, and there are people working at trying to develop those kinds of investment strategies all around at the world at this point right now. How successful, I don't know, but it would be a big leap forward.

The thing is, you've got to get the suppliers to bring down their price to the fuel cell companies, and that is going to be through large quantity purchases. So, some place we've got to get into forwarded pricing if we can.

Remember there are a lot of companies right now making a small fortune on fuel cells, Jack. Most of them started with large fortunes.

MR. SIMON: Jack, I wouldn't misunderstand my comments to say, you know, we as a company wouldn't be interested in the larger markets, it is just a question of where you start. The thing that I find hard to get beyond is if you read fuel cell energy's financial reports, for example, in the last quarter, they said we are doing better because now we are selling the product for a ratio between our cost and what we are selling it for of 3.5 to 1.

In other words, the actual selling price is less than 30 percent of what it cost to manufacture, and they said that is great because it is down from 5 to 1. If you look at their losses over the last four years, they have accumulated more than $400 million in losses. So, attacking the big markets, if that is where you are because of the small volume, means you have to have enormously deep pockets to do that versus going with markets that I am talking about whether the relationship between cost and price is the other direction. Price is twice what it costs you make. That seems to me to be something worth encouraging that you don't have to keep dipping into the public till in order to keep a company going.

MR. BROUWER: I agree. I just felt like we were leaving out the big as not even something we should invest in. I think we should have that on our road map.

MR. SIMON: Out in the future, but I think Mike made a great point. It takes somebody with really really deep pockets to get the volume up when you are doing it in big chunks at a time. So, I guess that is a policy question.

MR. REMICK: I can't argue with that. I am sorry, were you done? I can't argue with that either. In fact, it is one of the things we've been advocating too.

A lot of fuel cell companies have come and gone and many of them have used investor dollars. When you look at what some of them were trying to do, they were trying to -- it is not a big fuel cell size, but they were going after the residential fuel cell market. That became the holy grail that encouraged the investor to dump money into those fuel cell companies.

Within a year, within two years, you are going to have a fuel cell you can make your own electricity in your basement. They all disappeared became the market was too difficult, because the technology was too difficult to achieve.

What we need are these small nitch markets. We need to get out there now with the fuel companies that remain. They need to start showing they can make something, they can sell it in the market for a profit, even those -- these are the small nitch markets you are talking about so they encourage the industrious to hang in for the long run. It is going to be a couple of more years before you have the big MW fuel cells running you are selling for $1,500 a KW.

How do they get there? I would argue

that if you concentrate all your efforts, however, on the other side of the coin in making small five KW fuel cells for a remote market, that pretty soon you are going to discover your investors aren't interested in doing the big stuff anymore. So, you are still coming back to the Department of Energy, California Energy Commission for the money to get the technology developed for that long term market.

Jack, I agree with you. You've got to do something for the near term. You also have to have some kind of funding mechanism for the long term too.

UNIDENTIFIED SPEAKER: My question is sort of an off shoot of that question, which is how do you get fuel cells into the biofuel methane kind of nitch market in California in the Central Valley of California? A lot of people talked in the presentation today about California being the big -- that could be a big sweet spot for us in this state, and how do we provide the incentives to do something with fuel cells that fits into an environmental sweet spot or policy spot in this state, which is to reduce the global greenhouse gas emissions? If one of the incentives that have to be used is providing money for say digestors, is that something the CEC is willing to consider to couple with incentives for the fuel cell technology itself, so that we can get somewhere like the Central Valley and start to develop the biofuel markets?

DR. SOINSKI: Is that a question for me?

UNIDENTIFIED SPEAKER: No.

DR. SOINSKI: Okay, good.

MR. REMICK: Fortunately people --

UNIDENTIFIED SPEAKER: Oh, I'm sorry --

DR. SOINSKI: You are getting into the policy questions. You are absolutely correct, there is a big emphasis on greenhouse gas emissions. Some people think now it is going to be the big driver. It is probably going to overcome renewable energy and the California Solar Initiative, for example, is some of the thinking because it is going to become such massive consequence.

That is why one of the things is efficiency. One of the things I liked about Gary, and I think Kevin Harris had the same type of comment, is paying for performance. I never believed in the concept of paying for a KW. I think you should always pay for a KWh. Paying for performance is the way to go. If you are going to do demonstrations, paying for performance is the way to go.

Then there have been a lot of models of this. One was the Sacramento Municipal Utility District with photovoltaics in the early 1980's. They had the idea of putting in something like 100 MWs of PV.

They started with SMUD PV 1 and PV 2, and they had cost targets. The idea was dollar cost averaging. There is a concept of sustained orderly development. Both MC Power and ERC had collaborative with electric utilities where it was the same type of thing.

You give us a certain level of performance, and we will give you a guarantee buy. You look at all these, these are really failed experiments, and Dan Rastler and others can perhaps Stephanie could comment on why they are failed examples. I think there is a lot of benefit to that approach.

The difficulty is that I think this is what we are hearing is when you try to push a market that is not ready for the volume, you are not going to succeed. The idea of build up, build up, build up, you have to get down the cost curve simultaneously, and I think what's happened is in the past these companies have been overly optimistic as to how rapidly they could go down the cost curve.

As far as the policy question, that is going to be a significant driver and exactly where we go with biodiesel, I don't know, I think it is going to be a factor in our transportation funding, for example. It is in some of our budget plans. It has not been approved by the committee, the R & D Committee yet.

MR. SIMON: I think her question raises another interesting point, Art. Let's take the digester example because those are usually pretty big installations, so they actually make a lot of methane. By sitting on the Board of Directors at Capstone Turbine, you know, I can say that there is a company that will install a 60 KW micro turbine multiple quantities if you want at $1,500 a KW and do it for NOx emissions that are less that two parts per million and CO emissions that are about the same level.

That is about 31 percent efficient.

What does a fuel cell do that is better than that for that price, not much if anything. If the Energy Commission could help us identify places where the alternative is not a Capstone micro turbine or an engine and it is down in the 10 KW range where you don't have great alternatives and use that as a way to start a volume purchase and connecting some people up on that, and we can mature the technology from that base, I just think that has a lot to recommend.

Again, the performance that you would have soon if not right now at the smaller end is more likely to be something that you can get the customer to pay for, therefore, needing a smaller subsidy, but it builds the volume that Art was talking about.

You could set a price target out there, who is willing to build the fuel cells for this price and performance, and here is a set a customers we can link you up to. I think it is an interesting policy point, Art, to think about. Is it worth some time thinking about where these adopter customers are, even if they are small, even if it doesn't immediately go on the grid, although some of it could, as a way to achieve the objective of getting on to the larger scale systems that will have a significant impact on the electric system in the state.

MR. RASTLER: No hard questions. Dan Rastler with EPRI. You know, I travel all over the place in a lot of states in the country, and I see the interest in fuel cells.

Some states are really aggressive, Connecticut, Ohio are really taking on the opportunity, both economic development as well as some of the applications. I sit here in California and I am really frustrated that we have a great opportunity here for implementation of clean technologies of which fuel cells is one of them.

Picking up on Jack's comment, I hope the Commission will develop a road map for applications, and there needs to be a market pull. Most of the fuel cells are looking for a market, and we heard a nice dialogue about chasing propane in Iraq, but this is California. So, we need to create a vision of where these technologies fit in.

That vision needs to include stakeholders that can create a market pull, and

Marianne left, but there is enough money to fund stuff, and I disagree with we just had enough money to buy down the volume because I think we've gone down that pathway a couple of times before with not very favorable results, but a win/win partnership where we have a market pull.

Utilities, perhaps end users, maybe it is the manufacturing, California Manufacturing Association, other end users are involved in that process of shaping the road map. Phosphoric acid and carbonate systems can play near term into that vision because they are very much here today.

Emerging companies like Gary's and others need the sense of market certainty. They need to know that there is markets that will adopt a technology once it is proven and it is ready. Not to fund technology development, but to provide closure of gaps around market uncertainty. So, I think that could be a very useful role for the Commission, not only in fuel cells, but in the distributed generation market in general.

So, not really a question, but a comment that as you think about your road map, think about a vision of what California could be with clean environmentally friendly technologies, how that would fit into the overall energy landscape and what would be the markets and how the markets can pull the companies represented into those solutions. That is just a comment.

DR. SOINSKI: Anybody else? We still have a good audience. Mickey.

MR. OMS: My name is Mickey Oros. I am with Altergy Systems. We are a PEM fuel cell developer. We have been somewhat quiet over the years because we really didn't want to actually broadcast until we had a product that we could bring to market.

One of the things that we've found that is low hanging fruit and Mike mentioned it was because of 9/11, East Coast Blackout, Katrina, we found in the telecom industry that back up power is needed because the federal government now is coming through and asking for hardening of the sites.

When we looked at the telecommunications industry today, we see the battery back ups are only good for two to four hours in some cases and not enough for them to sustain the long operations. In Katrina, the biggest complaint was a lack of communications.

This is my comment by the way, it is not to ask a question, but I just wanted to add some other things with regards to fuel cells that people are not considering. We are looking at the MWs I think and CEC is looking at. A two MW doesn't even put a blimp on the CEC's outlook for output of energy per year, and that just came from Dave Ashuckain upstairs when I talked to over lunch.

With fuel cells, what we are seeing is and especially in this telecom back up and Plug Power is along with that. In fact, Hydrogenics mentioned it this morning, we do have low hanging fruit in the sense that when we start building fuel cells for $2,500 and $3,000 a KW in those ranges, we are not getting any repercussion at all from the telecom industry. They are saying why not, bring it on.

The reason for that is like I said earlier, the government wants to start to harden sites. When we start talking about hardening sites, they want 24 to 48 to sometimes 72 hours worth of back up. Batteries just can't do that today.

We have a wonderful opportunity at the

price that we are offering these fuel cells to them to go ahead and immediately walk into a markets today that will easily go ahead and take care of this industry.

With SGIP Program, the Self Generation Incentive Program here in California, we are trying right now to have the PUC see their way through to allowing back up generators to be incorporated in the SGIP.

If that takes place, that will put about $2,500 per KW in credit towards the fuel cell purchase. That would bring us easily down to today's batteries, back up power, what have you. When the industry takes a look at back up power for telecom industries, by the time they put the batteries in with all the O&M expenses, with all the back up generator, the diesels or what have you to go ahead and complete and take care of that back up, it is very very costly.

I just wanted to make a point. I just hope that one would see clear that back up generators with fuel cells are very viable in fuel cells today, but it does make a market and it should be considered as a viable piece of product into the market place.

One of the other things is, and I think what is happening in the Finance Department here in this state and others, they are not looking at life cycle costs. Fuel cells are the type of devices that you know there is that old adage, pay me now or pay me later. Well, with fuel cells, there are benefits in a longer period of time in life cycle that isn't considered.

I think the procurement officers sometimes take a look at it and say, what are we going to get out of it in the next year or two or maybe three years. I think really life cycle costs in some fuel cells need to be looked at on a much longer time frame, and I think that is another piece that we need to consider in here actually when the purchases take place looking at life cycle costs.

That is about it, but it is just a comment.

MR. REMICK: If I may ask one question of the speaker. You know, Hydrogenics and you have Plug Power who are already now providing or selling products to that market, back up to telecommunications.

Is there really any research or money

that you think the California Energy Commission should be investing in that particular technology or is this already "commercial" and it is out there?

MR. OROS: Plug along with me sitting next to me over there, maybe she could make a comment, but I think there needs to be more investment on it, sure. When we take a look at cell communication tower sites alone, we have nearing almost 200,000 in the majors. I am talking Nextel, Sprint, the Verizon's.

That excludes all the private entities, the CalTrans, the Highway Patrol, Office of Emergency Services, everything that could possibly go down during a catastrophe. Not only hurricanes, but what happens with earthquakes and various other things that are acts of God that could happen where PG & E could go down for days, but yet we have a lack of communications.

It is getting near commercialization. It is going to take a few more years to actually mature it and have working pieces in the market place to go ahead and take a look at those things, but I think it is nearing it, but we still need subsidies, and the SGIP is one program that could really aid and assist us in trying to further our development than what we are doing.

MS. MOORE: One of the things that we are seeing more and more out there is that there is that sweet spot that nitch market for the power back up, but it is still a new technology to a lot of people, and people are looking for the incentive programs and some back up funding and things like that to kind of get the sense that the industry is going to be there.

So, yes, to help us with some of these programs is definitely looking to the Energy Commission and the PUC incentive programs to help us get the technology out there. Obviously the more incentives there are out there, the more product that goes out there, the cost will down.

It is a cycle that we are all very well aware of, so, yeah, we are looking for some additional incentives on funding.

Thank you.

MR. OVSHINSKY: Ben Ovshinsky, just a small comment on back up markets. We've seen that some of the competition is going to be hydrogen, but from another form, hydrogen ICE gen sets, which are commercial in Hong Kong.

I don't know, Mickey, do they run 72 hours? I don't know about that, but with Ford V-10's and whatever.

Another comment on the harden the market, I was thinking someone else has touched on it, another market curve and driver is something that is unforseen when the shock to complacency of existing markets takes place, like the 9/11 which opens up the ideas of energy security, energy independence, and ties into with Homeland Security and natural disasters that disrupt life completely for squares of millions of people.

Those kinds of factors which seem to be fairly new in the market that we've been living in. That is a curve and that is a pressure to maybe paradigm shifting and maybe fuel cells will look a lot better in those contexts.

DR. SOINSKI: Anybody else? Don't run away. Bob, are you ready to give us a wrap up? Show us the highlights?

MR. TAYLOR: A short wrap up.

DR. SOINSKI: That's okay, five minutes, three minute. This is Rob Taylor from SEIC, one of our technical systems contractors, and we asked him in the absence of my being able to take notes to try to just throw out some of the high points, and he has not had the benefit of the presentations, I mean, hard copies of the presentation.

MR. TAYLOR: I just wanted to reread the purpose that we started out with, and that was to assist PIER in identifying critical opportunities for future investment in fuel cells. That included technology issues as well as ratepayer benefits.

Also, critical interdependencies, which are policy issues and market issues. I think we pretty much addressed all of those.

We went through several presentations starting out with Martha Krebs going through and discussing the PIER Program as well as the California energy requirements. We heard a presentation from Nancy Garland from DOE who talked about the U.S. DOE Program on Fuel Cells and presented a very good road map, which I think will be valuable for the California Energy Commission even though the CEC may have a little bit different objectives and certainly shorter term objectives.

I thought there was a very interesting

presentation by Marianne Wu, sort of a little bit different from most of the other presentations dealing with the investor market out there. I thought it was very interesting that she said there is a real interest in the investors to be interested in various type of energy technologies including fuel cells.

Then we heard from Stephanie Hamilton from Southern California Edison who I think just left and gave us a little bit of the utilities' perspective and the fact that they are looking very strongly at distributed generation. I think her presentation was a little broader than fuel cells, but certainly it points out a lot of the advantages of distributed generation and maybe points us to where those nitch markets are for fuel cells.

We then went into specific sort of categories, transportation fuel cells and then later the stationary fuel cells, and we heard the presentations from Charles Stone on PEM fuel cells and also from Kevin Harris, who maybe presented a lot of specific things that maybe he would like to see the California Energy Commission do to incentivize or support fuel cell development in

California.

Then of course Ken Koyama from the California Energy Commission presented a lot of the transportation programs not only in California, but nationally and internationally.

Then we just followed up with this panel discussion on stationary fuel cells, and I think the panel discussion went very well. We got a lot of input and, of course, we had Mike Binder talking about phosphoric acid fuel cells and Bob Remick talking about molten carbonate fuel cells, and Gary Simon on solid oxide fuel cells.

I found the closing panel here was very good. It brought out a lot of intriguing questions about the technology, what the costs are, what are the barriers we are facing, what are the markets that we should be identifying.

Backing up just a little bit, there was one thing that Marianne Wu said that I thought was pretty critical. She said that we should be looking at the markets that we want to serve as opposed to the technology that we have.

I think that goes back to that old saying to the guy that has a hammer, everything looks like a nail, but maybe we need to find out what are the nitch markets, where are those early entry markets and the low hanging fruit and concentrate on those, then the rest will kind of fall in place.

I follow the photovoltaic industry, and I think we have referred to the photovoltaic industry quite a bit, and I think they started looking at remote sites, a lot of really unique applications for protection of remote, repeater stations, and all of the sudden, they are growing at 20 percent per year. A lot of that growth is in places like Germany where they are installing them on commercial buildings or the United States where we are installing in grid connected applications.

The same is true in Japan. So, I would contend that we do need to look at some of the cost effective early entry markets, and I think at the same time as some of the other people asked questions, we do need to develop a road map that looks further out.

I would say that this has been a very successful day, and we have presented a lot of information which now the Energy Commission can start looking at to try to develop that road map to move forward.

UNIDENTIFIED SPEAKER: I just have a quick question. Are these presentations going to be available on line?

DR. SOINSKI: The question is exactly when and where. Probably within the next day or two, and probably see if you can get a link through the calendar. Go to May 31, go to this workshop, and then hopefully, there will be a link that will then get you to it. That would probably be the easiest way if we can get the webmaster to do it that way. We will leave the announcement on and then easily download it.

Thank you all. This is great attendance. I appreciate some of you staying so late. If you are going to remain in Sacrament, I hope you have a good time tonight and for as long as you stay. Thank you for coming.

(Whereupon, at 5:00 p.m., the workshop was adjourned.)

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CERTIFICATE OF REPORTER

I, CHRISTOPHER LOVERRO, an Electronic Reporter, do hereby certify that I am a disinterested person herein; that I recorded the foregoing California Energy Commission workshop; that it was thereafter transcribed into typewriting.

I further certify that I am not of counsel or attorney for any of the parties to said workshop, nor in any way interested in outcome of said matter.

IN WITNESS WHEREOF, I have hereunto set my hand this 9th day of June, 2006.

Christopher Loverro